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The Petroleum Engineer

DALLAS, TEXAS

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TRET-O-LITE

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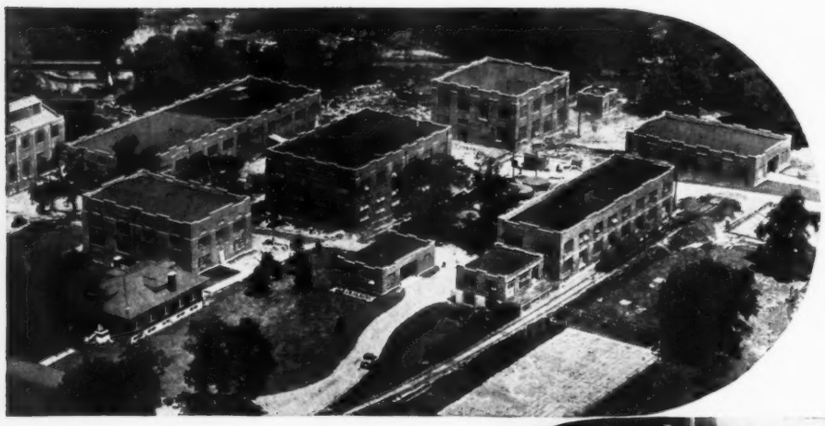


The Company behind Tretolite countenances no rule of thumb methods. A group of modern well planned buildings houses up-to-date well equipped laboratories that continuously carry on exhaustive research work in every known form of cut oil. The economy and dependability of Tretolite formulas are assured by such exacting far reaching development as conducted in

these laboratories over a period of years. Tretolite Advisory Service is maintained to assist you in your treating problems. It is available quickly regardless of your location.

TRETOLITE COMPANY

MANUFACTURING CHEMISTS

DALLAS **SAINT LOUIS** **LOS ANGELES**

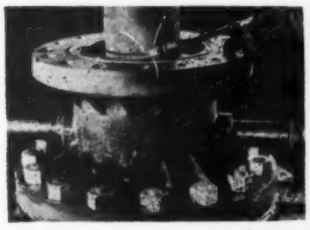
Representatives in all Principal Fields

Only in the SHAFFER SPOOL TYPE LANDING HEAD CAN YOU GET THE "BIG 4"

WHAT COULD BE SIMPLER? . . .

LANDING CASING WITHOUT "LETTING GO," MEASURING OR RETHREADING!

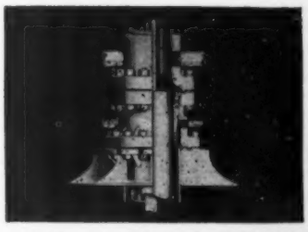
Run the casing in the hole, take stretch if required and insert self-aligning slips



With torch cut off casing flush with top of landing head

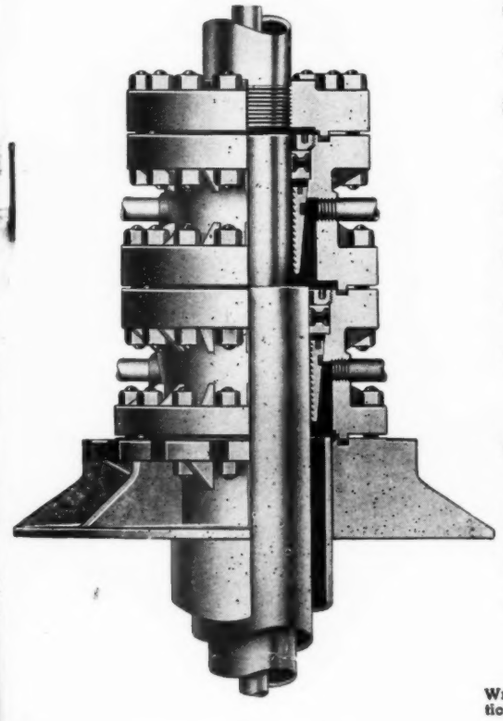
Casing is ready to be packed off.

Place packing unit around the casing above the slips.



Drilling connections are flanged to top of landing head or may be attached directly to the casing landed in the slips.

Shaffer Spool Type Landing Heads are made in two standard types. Type "A" is recommended for pressures up to 3000 lbs. Type "B" (illustrated) for pressures up to 6000 lbs.



1 Each individual string is landed with safety at any point desired without any necessity for "letting go", measuring or rethreading.

2 Each string is supported on its own flange with an upper flange provided for the support of the next string.

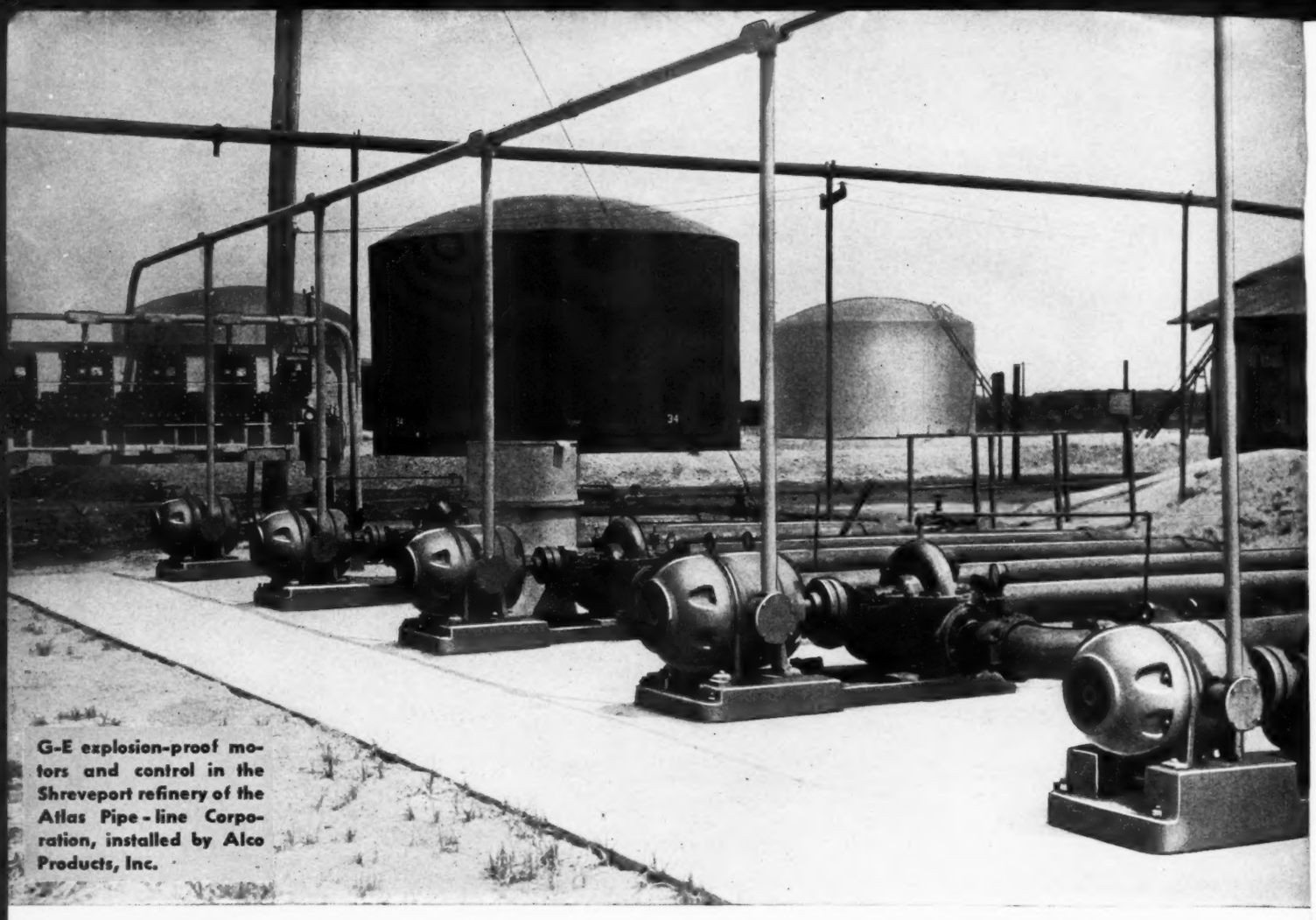
3 Each string is suspended on its own set of slips with no accumulation of weight put on those slips by subsequent strings of casing and tubing.

4 Each string is packed off securely against high pressure with provision for gas outlet, mud line or overflow as required.

Write for the 1936 Shaffer Catalog or see the Shaffer Section in the Composite Catalogue. It starts on page 1143.

SHAFFER TOOL WORKS

Brea, Calif.—Houston, Texas—Export, Oil Well Supply Company.



G-E explosion-proof motors and control in the Shreveport refinery of the Atlas Pipe-line Corporation, installed by Alco Products, Inc.

Why General Electric Equipment Keeps Pumping Costs Low

Economical to Install

Special enclosures do not have to be built over G-E explosion-proof motors and control. These equipments are truly weatherproof, as shown by the installation pictured above.

Gives Maximum Protection for Employees

The G-E explosion-proof motor, with its dust-tight construction and cartridge-type ball-bearing housings with labyrinth seals, gives maximum protection. The control, too, is of explosion-proof design.

Tested by Underwriters' Laboratories

These G-E explosion-proof motors and starters are built to the standards of the Underwriters' Laboratories for service in Class I, Group D, hazardous gas locations. Each motor bears the Underwriters' label; the control is tested and listed by the Laboratories.

Whatever the job, we can supply the explosion-proof electric equipment for your refineries—motors of every type and size; control, from push-button stations to oil-immersed magnetic switches. General Electric, Schenectady, N. Y.

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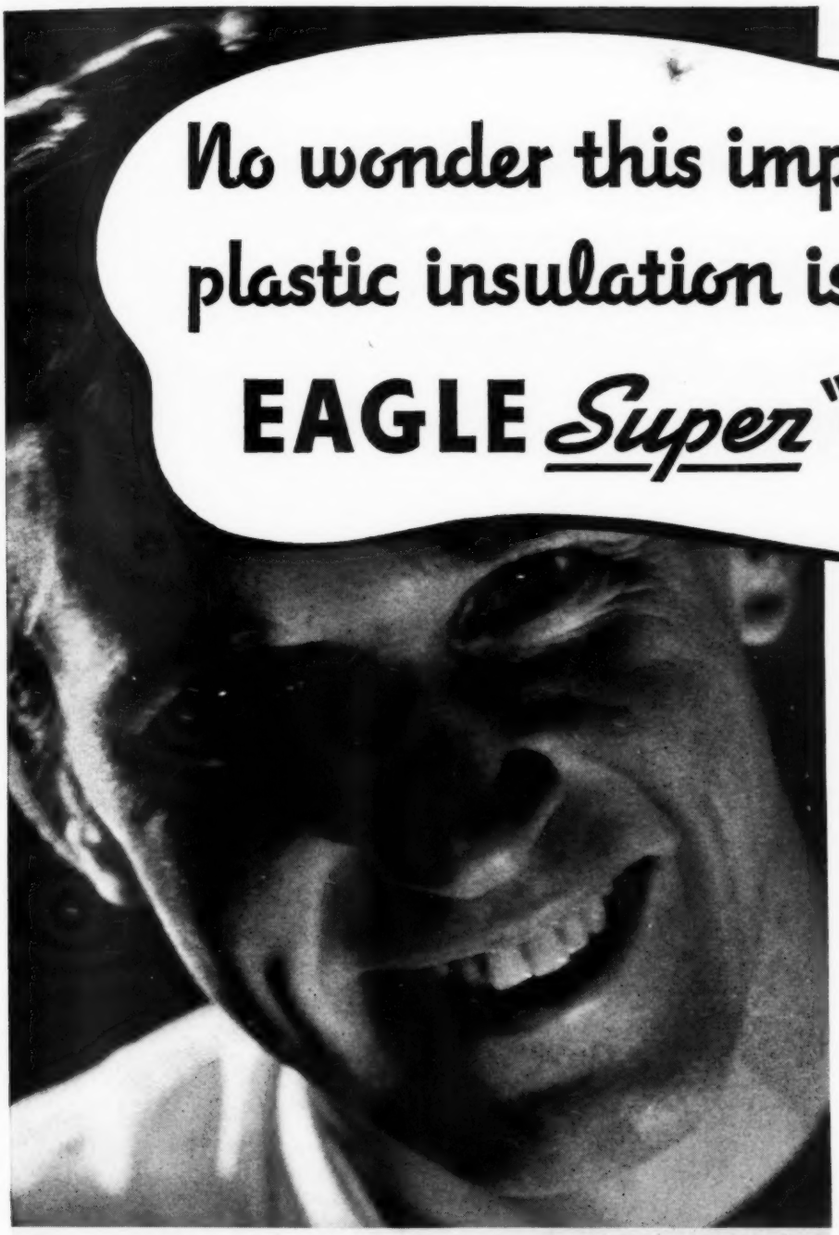
GENERAL ELECTRIC



No wonder this improved plastic insulation is called EAGLE *Super* "66"!

GREATER COVERAGE
100 lbs. of Eagle Super "66" covers 60 square feet in 1-inch thickness! Goes farther — and shrinkage is minimized.

EASIER TO APPLY
Eagle Super "66" can be mixed with water and troweled on at once. Goes on any smooth or irregular surface.

REMARKABLE EFFICIENCY
Eagle Super "66" is efficient for temperatures as high as 1800° F.... is 100% reclaimable up to 1200° F.!

Eagle-Picher manufactures a complete line of Insulating Materials for Refineries

Eagle Blanket Insulation. Insulating wool felted and secured. For boilers, breeching, furnaces.

Eagle Stalastic (boiler setting cement). Tough, rubbery plastic—eliminates air infiltration through masonry, boiler, furnace walls.

Eagle Insulseal (waterproofing cement). Durable coating protects all heat insulation against deterioration.

Eagle Fireproofing Concrete. High grade insulating concrete that furnishes dependable fireproof protection to structural members.

Eagle "BX" Insulating Brick. An extremely strong, light weight insulating brick. Easy to cut. Resists spalling. For temperatures up to 2500° F.

Eagle "Verox" Insulating Brick. A light weight, efficient insulating brick for backing up refractory walls or roofs. For temperatures up to 2000° F.

Eagle Asbestos Lumber. Structurally strong. Fireproof. Resists heat and weather.

Eagle "77" Pipe Covering. Insulating wool felted and secured. Flexible and easily applied. Particularly adapted for hot lines where a cement finish is desired.

EAGLE INSULATION SERVICE for Oil Refineries

MAIL COUPON today for free sample and complete specifications.

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Dept. PE6, Cincinnati, Ohio

Please send me, free, your illustrated booklet, "Effective Heat Insulation."

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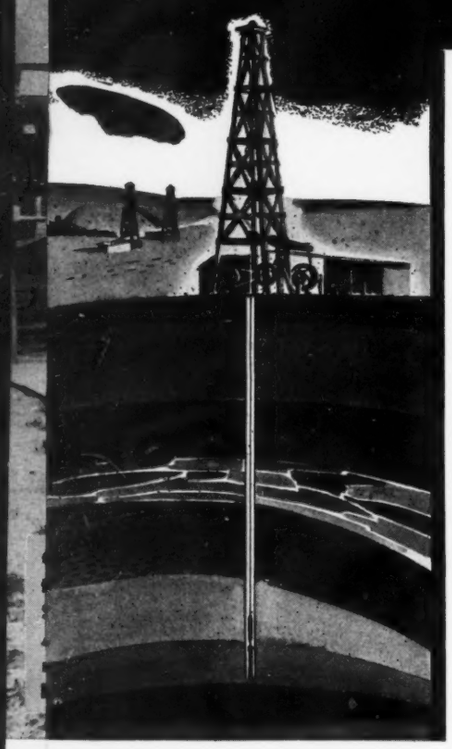
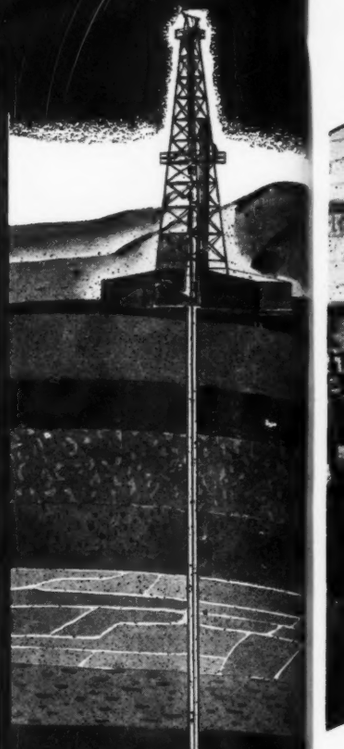


• • • • WHETHER YOU ARE DRILLING IN SHALLOW FIELDS WITH CABLE TOOLS OR TO GREATEST DEPTHS WITH ROTARY RIGS . . THE CONTINUOUS USE OF

AQUAGEL

WILL ELIMINATE LONG, EXPENSIVE DELAYS AND SAVE MONEY



ADVANTAGES of AQUAGEL IN CABLE TOOL DRILLING

No. 1 — *Prevents Caving and Sticking of Tools.* By mixing 17½ lbs. of dry Aquagel to a barrel of water, then placing 2½ bailers of this fluid in the bottom of the hole, cuttings will not settle and stick tools. In addition, a sealing film will be plastered on the walls of the hole to prevent caving.

No. 2 — *Aids Casing Recovery.* A mixture of 24½ lbs. of Aquagel per barrel of water placed in the annular space between casing and formation will almost assure 100% casing recovery. Aquagel so placed helps prevent sloughing of the formation around the casing and in addition provides a lubricant for its recovery.

No. 3 — *Cuts Down Recovery Time.* Field experience has proved that by using Aquagel the time spent in recovering casing is reduced by more than half.

No. 4 — *Prevents Corrosion.* The gel-forming colloidal material in an Aquagel-water mixture provides a coating which minimizes the effects of corrosion on the casing.

ADVANTAGES of AQUAGEL FOR ROTARY DRILLING

No. 1 — *Provides Wall-Building Properties.* The addition of Aquagel to drilling mud causes it to build a thin impervious film on the face of the formation, preventing the seepage of water and thus helping to prevent caving.

No. 2 — *Removes and Suspends Cuttings.* Suitable viscosity to pick up cuttings and suspend them in the hole can be easily maintained by the addition of Aquagel to the mud system.

No. 3 — *Helps Prevent the Loss of Circulation.* Aquagel added to drilling mud helps to seal and consolidate formations and often lost circulation can be restored by adding increased quantities of Aquagel to the mud.

No. 4 — *Prevents Sticking of Drill Pipe.* An adequate viscosity can be maintained by the addition of Aquagel to the mud system which will suspend sand and shale cuttings indefinitely when circulation or rotation is stopped.

No. 5 — *Prevents Wear.* The colloidal nature of Aquagel acts as a lubricant to pumps and all moving parts as well as to the casing and walls of the hole.

No. 6 — *Combats the Effect of Temperature.* The high temperatures encountered in deep wells have a detrimental effect on the wall-building qualities of mud. This characteristic can be preserved when Aquagel is added in correct amounts.

No. 7 — *Facilitates Mud Control.* It is easy to control the viscosity and gel-strength of muds to which Aquagel has been added because of the highly concentrated colloidal material which is present in Aquagel.

BAROID . *Extra-heavy Colloidal Drilling Mud*

AQUAGEL . . *Trouble-proof Colloidal Drilling Mud*

STABILITE . . *An improved Chemical Mud Thinner*

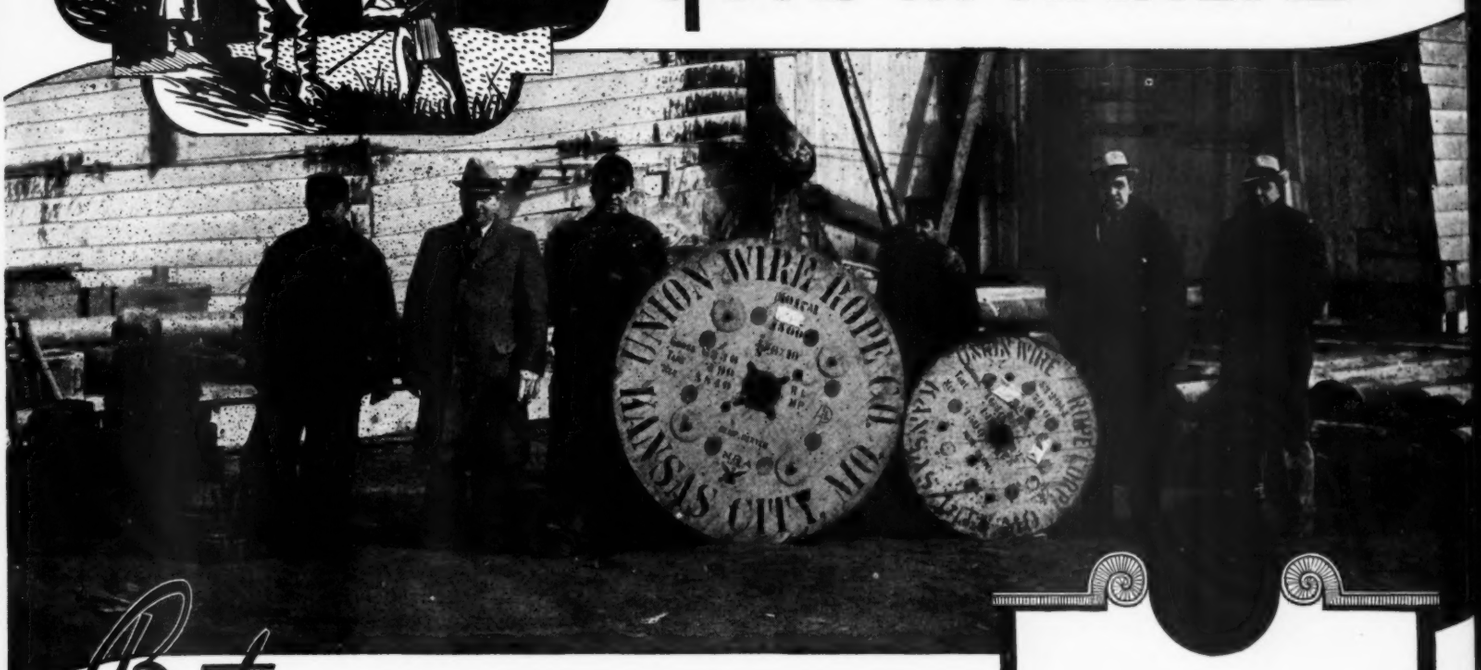
BAROCO . . *An Economical, salt water-resisting Drilling Clay*

FIBROTEX . . *An effective material for preventing or regaining lost circulation in drilling wells*

Stocks Carried and Service Engineers Available in all Active Oil Fields

BAROID SALES COMPANY

CORONADO *found no* gold in KANSAS



But UNION WIRE LINES *find "gold" there now!*

Historical research proves that Coronado and his band of 36 Spanish adventurers explored Kansas only 49 years after Columbus discovered America and 44 years before Raleigh planted the first white settlement in America at Roanoke, Virginia. After failing in his search for gold, Coronado returned to Mexico feeling that his daring and difficult expedition had been fruitless.

But in this same region where Coronado found no gold, UNION Wire Lines today are finding "black gold" in plenty. It is an interesting coincidence that Coronado brought his search for treasure to an end at the Indian city of Quivira in what is now Rice County, and that oil interest in Kansas is focused on Rice County at this time. Throughout the oil fields of this very active oil state, UNION Wire Lines have become leaders and favorites because of their exceptional durability.

The photograph shows the Equity Gas Company's "Cora Shaffer Well No. 1," being drilled with UNION Lines near Bunker Hill, Russell County, Kansas. The men, left to right, are: J. A. Saling, farm boss; Jess Hunt, Jarecki Mfg. Co.; Grit Burke, driller; Harry Kessler, tool pusher; H. M. Humphrey and H. E. Frye, Union Wire Rope Corp.

DESCRIBED KANSAS AS "LAND OF PLENTY"

Though Coronado failed to find Quivira a "city of gold," and though he abandoned there his search for golden cities, he reported Kansas a "land of plenty," writing to the King of Spain:

"The country is the best I have ever seen for producing all the products of Spain, for, besides the land itself being very fat and black, and being well watered. . . . I found plums like those of Spain, and nuts and very good sweet grapes, mulberries, elderberries, succulent buffalo beans, sheep sorrel, ground cherries, wild onions, Indian turnips, walnuts and pecans." He found the Quivirans growing crops of corn, beans, melons, squashes and pumpkins."

Coronado brought into Kansas the first horses the Indians had ever seen.

UNION WIRE ROPE CORPORATION

Executive and Sales Offices: 601 Beacon Life Bldg., Tulsa, Okla.
Factory and General Office: Kansas City Mo. Branch: Portland, Ore. Warehouse: Monahans, Texas

In Mexico: E. O. CHAPA, P. O. Box 604, Tampico, Tamps, Mexico. Stocks at Tampico

JARECKI MFG. CO.
Distributors: Midcontinent, New Mexico and Eastern Oil Fields

MARION MACHINE FOUNDRY & SUPPLY CO., Rocky Mountain Fields, except New Mexico

Export Agents: (except Mexico) LUCEY EXPORT CORP., Woolworth Bldg., New York; Broad St. House, London

UNION WIRE LINES

The "ULTIMATE LOW COST WIRE ROPE"

AFTER RUNNING YOUR FIRST STRING OF *Chester Special Casing* YOU BECOME A BOOSTER

Almost daily we receive reports from the field commending us on the fast running of *Chester Casing*. This is due to our accurate threading which tends to make a fast running and perfect joint.

Chester Casing has a minimum of 40,000 pounds elastic limit — 70,000 pounds tensile per square inch and a hardness of 145 Brinell.

A Few Reports That Come In

One hour's time saved in running string over other makes.

•

Customer said, "We are well pleased with the accurate threads."

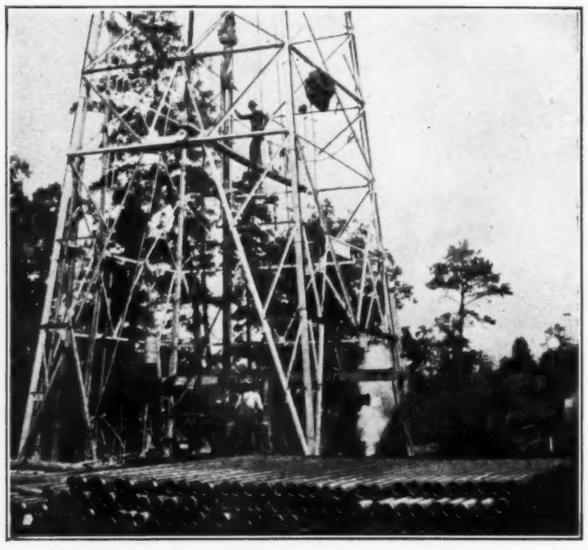
•

Not over a half thread variation in the whole string in making up.

•

Superintendent reported "The most perfect joints we ever ran."

•



A Few Reports That Come In

Another Tool Pusher said: "Am well pleased with it and it was a beautiful string."

•

Tool Pusher — "Never ran nicer Casing."

•

General Superintendent well pleased with reports from his field men regarding easy running of Chester Casing.

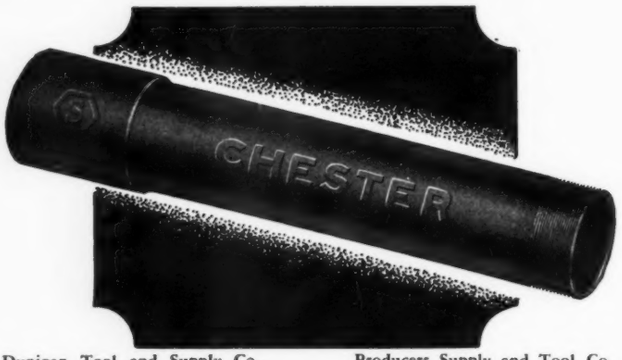
•

Another was skeptical — now a booster.

•

SOUTH CHESTER TUBE CO.

CHESTER, PENNSYLVANIA



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J. P. Cooney, 715-716 A. G. Bartlett Bldg., Los Angeles, Calif.

J. P. Steele, 603 Petroleum Bldg., Fort Worth, Texas.

District Offices

South Chester Tube Co., 1708 Hudson Terminal Bldg., 30 Church St., New York, N. Y.

J. D. Swartz, 608 Beacon Bldg., Tulsa, Oklahoma.

E. L. Moseley, 2218 Mills St., Houston, Texas.

Burt S. Shafer, Southwest Representative, 4313 Fairfax Avenue, Dallas, Texas, or 603 Petroleum Bldg., Ft. Worth, Texas.

District Warehouses

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Distributors

Western Supply Co., Tulsa, Okla. and Branches.

International Supply Co., Tulsa, Okla., and Branches.

Dunigan Tool and Supply Co., Breckenridge, Texas, and Branches.

Bridgeport Machine Co., Wichita, Kansas, and Branches.

Producers Supply and Tool Co., Marietta, Ohio; Fort Worth, Texas, and Branches.

Louisiana Supply Co., Sulphur and Brimstone, La.

Oil Field Equipment Co., San Antonio, Texas.

Okmulgee Supply Corp., Okmulgee, Okla., and Branches.

Stephen H. McCabe, 508 4th St., San Francisco, Calif.

Viking Automatic Sprinkler Co., 114 Sansome Street, San Francisco, Calif.

Herley Supply Co., 3006 Cherry Ave., Long Beach, Calif.

Barde Steel Co., Seattle, Wash., and Portland, Ore.

Star Drilling Machine Co., 550 Clinton St., Portland, Ore., and Akron, Ohio.

The Atha Supply Co., Zanesville, Ohio, and Mt. Pleasant, Mich.

United Pipe & Supply Corporation, Charleston, W. Va., and Branches.

Bovaird & Co., Bradford, Pa.

Kane Supply Co., Kane, Pa., and Branches.

Prichard Supply Co., Manningtton, W. Va., and Branches.

LeValley, McLeod, Kinkaid Co., Elmira and Olean, N. Y.

CHESTER

STEEL CASING AND LINE PIPE

DIRECT DRIVE IS THE *big news* IN ROTARY DRILLING

These new units consist of either a 26" Model 34 Make-and-Break Rotary or a 27½" Model 35 Straight Rotary, direct-driven through a gear box by the "OIL-WELL" No. 7 (7¾" x 7") Vertical Twin-Cylinder Piston Valve Steam Engine—all mounted integral on skids for convenience and portability.

SINCE "Oilwell" developed the first Direct-Driven Rotary Drilling Unit, it has been thoroughly tested—first at Kettleman Hills and since then in many other fields. Production men like it because it does the job more efficiently at a lower operating cost.

Here is a list of its advantages—

1—Eliminates operating hoist and hoisting engine 90% of the time. Does away with replacements of rotary chain and sprockets, and with rotary chain noise (driller can hear himself talk). Reduces wear and tear on rotary, hoisting engine and hoist.

2—Saves fuel, steam and lubricating oil because engine (a) efficiently handles rotary table load; (b) equipped with hand controlled variable steam cut-off makes use of expansive force of steam; (c) saves power because it is unnecessary to drive hoist mechanism.

3—Simplifies drilling rat hole; makes spudding easier, provides an effective means of "drilling up" thus eliminating fishing jobs when "bridges" are formed above the bit; saves time in breaking out the drill pipe—no clutches to throw, nor is engine reversed.

4—Is light, portable and easily hauled; saves floor space; has ample capacity for deepest drilling. Provides auxiliary prime mover to handle emergency hoisting needs.

5—Gives longer life to drill pipe and bits; will drill straighter hole with same weight. Pays for itself in tangible savings.

To get more complete data on "Oilwell" Rotary Drilling Units, ask for Bulletin No. 145 at any "Oilwell" Branch Store.

OIL WELL SUPPLY COMPANY

Subsidiary of United USS *States Steel Corporation*

Branch Stores in All Oil Fields

"OILWELL"

LOOK T

IN ALLOY STEELS

Republic is the world's largest producer of alloy steels for drilling bits.

Republic Agathon Alloy Steels were used in the rotary drilling of the world's deepest oil well . . . 12,786 feet. Check the recently published list of the thirteen deepest oil wells in the world and you will find that Republic Agathon Alloy Steels were used for the bits on all thirteen jobs.

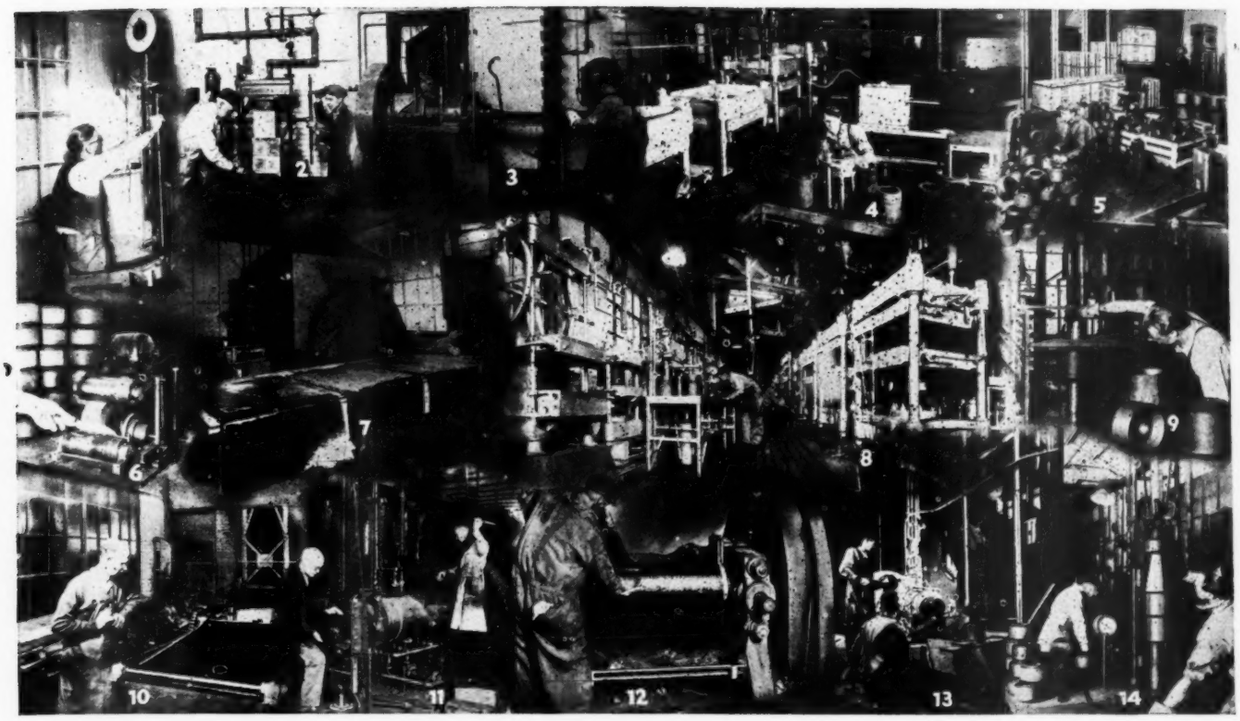
If you have a problem in steel . . . if you are looking for better performance from rotary drilling bits, drill collars, reamer bodies, swivels, wire rope, chains, tool joints or other severely stressed applications, look to the leader in alloy steels. Republic Metallurgists are at your service . . . Write to Department PT.

REPUBLIC STEEL

Republic Steel CORPORATION

ALLOY STEEL DIVISION, MASSILLON, OHIO
GENERAL OFFICES: CLEVELAND, OHIO

When writing Republic Steel Corporation for further information, please address Department PT



1. Testing rubber for tensile strength. 2. Preliminary cure test. 3. Tubing seamless Protector slugs. 4. Loading and unloading compression moulds. 5. Testing finished Protectors. 6. Trimming excess stock. 7. Dusting stock preparatory to sampling. 8. Battery of presses in curing department. 9. Removing cores after curing. 10. Applying weatherproof coating. 11. Tubing stabilizer stock. 12. Masticating initial mix. 13. Checking weight of slugs. 14. Final expansion test, duplicating field operation.

"THEY'VE MADE THEIR WAY BY THE WAY THEY'RE MADE"

The above photo shows several phases of production in the Patterson-Ballagh Protector plant. It is the only plant in the world devoted exclusively to the production of rubber for pipe and casing protectors. Processes have been highly developed to insure the toughest, strongest, most enduring rubber for this severe service. Every batch of rubber is painstakingly tested. The rubber must meet a breaking strain of nearly 5,000 lbs. to the square inch and an elongation of approximately 800%. Patterson-Ballagh Protectors are the product of eight years' specialized development. We have prepared interesting literature giving pertinent facts about the manufacture of casing protectors. This will be sent upon request.

PATTERSON-BALLAGH PROTECTORS

All-Rubber *The Genuine*

PATTERSON - BALLAGH CORPORATION

Plant and General Offices: 1900 East Sixty-fifth Street, Los Angeles, Calif., U. S. A. • New York Office: 39 Cortlandt Street
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Every part accessible **for easy adjustment** *. . . out in the field*

IT TAKES A PRACTICAL INSTRUMENT to earn the reputation for low-cost accuracy which Westcott orifice meters enjoy throughout the world.

That simplicity of design and experienced engineering are primarily responsible, is obvious to any engineer familiar with flowmeter operation.

But Westcott orifice meters and flowmeters go still further in giving you a **PRACTICAL** instrument; all parts are made for easy adjustment with ordinary tools. A minor feature of Westcott meters, to be sure . . . but one more important detail in reducing the cost of accuracy out in the field.

New literature is complete with data on the design and application of these instruments. Specifications are now available also on the popular new Round Case Indicating Flowmeter.

AMERICAN METER CO. CENTENNIAL 1834-1936

AMERICAN METER COMPANY
INCORPORATED
Measurement and control of Gas, Oil, Steam, Air and Liquids
ESTABLISHED 1836

METRIC METAL WORKS • ERIE, PENNSYLVANIA

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THE Petroleum Engineer

JUNE 1936

VOLUME VII NUMBER IX

A MAGAZINE OF METHODS FOR OPERATING MEN

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Meetings

American Society of Mechanical Engineers, Semi-Annual Meeting—June 15, 16, 17, 18, 19, and 20, Dallas, Texas.

•

Pennsylvania Grade Crude Oil Association, Annual Meeting — June 18 and 19, State College, Pennsylvania

•

American Society for Testing Materials, Annual Meeting—June 29 to July 3, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

•

California Natural Gasoline Association — July 2, Richfield Building, Los Angeles.

•

Interstate Oil Compact Commission —July 31, Dallas, Texas.

•

American Chemical Society, Semi-Annual Meeting—September 7, 8, 9, 10, 11, and 12, Pittsburgh, Pennsylvania.

•

American Petroleum Institute, 17th Annual Meeting — November 9, 10, 11, and 12, Chicago, Illinois.

•

Independent Petroleum Association of America, Annual Meeting—November 30-December 1, Biltmore Hotel, Oklahoma City, Oklahoma.

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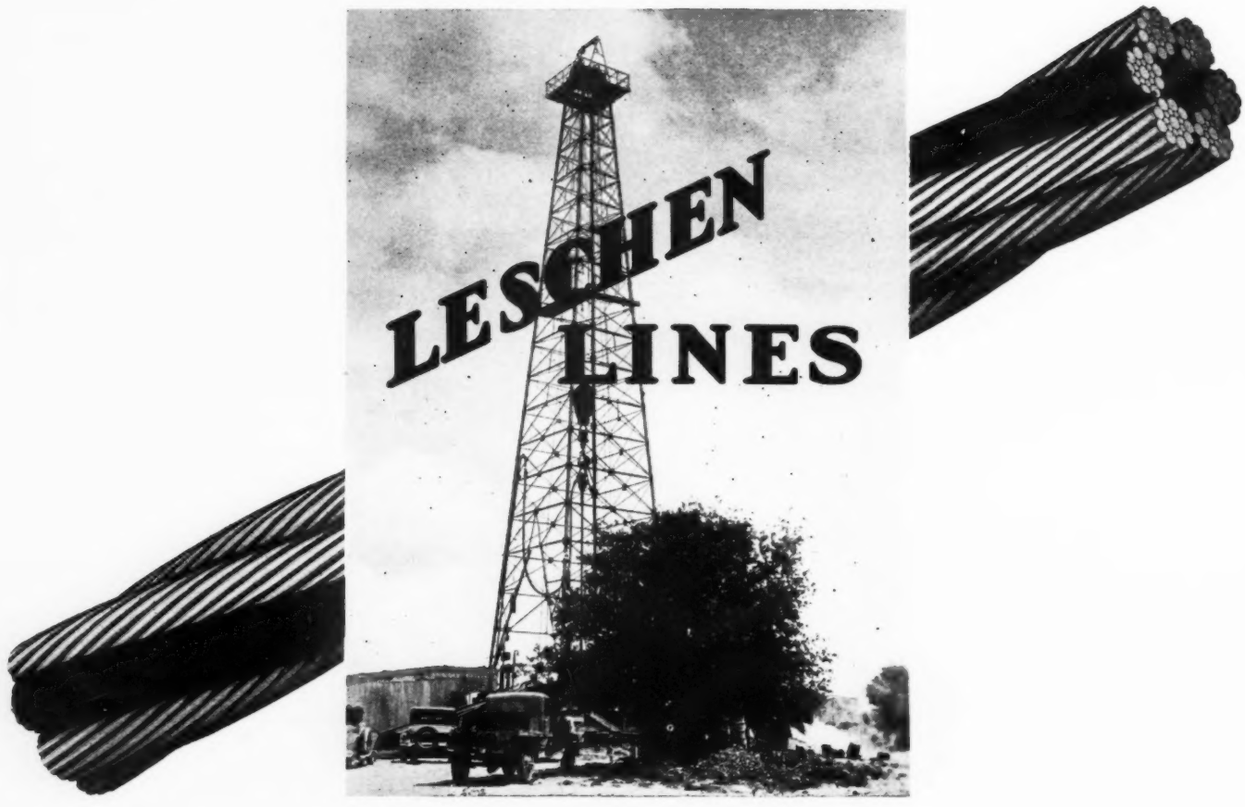

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The Course of Oil

By K. C. SCLATER

An Executive Speaks

Most of the statements that follow reflect viewpoints that are refreshing, to say the least—and worth noting, coming as they do from one of the leading executives in the Mid-Continent. They are highlights of a remarkable address, "Economics of Oil Producing Practice," delivered recently by C. H. Lieb, President of the Carter Oil Company, before a special meeting of the Mid-Continent Section, American Institute of Mining and Metallurgical Engineers, held at Tulsa, Oklahoma.

"Probably the most advanced engineering thought in the oil producing business today is the possibility of attaining recovery of all the oil in a reservoir by use of the energy inherent in that reservoir without the addition of any power from outside sources."

"Proration, today, signifies merely a restraint upon production, and it is far from being in its most desirable form. Theoretically, proration should be synonymous with efficient producing practice as applied to any pool. Largely, however, because the administration is in political bodies, it is subject to political exigencies and consequently is a compromise which leaves much to be desired. Proration was first conceived as an implement to balance 'supply and demand.' It is still so regarded by many people and without critical attention to efficient rate of production. The underlying purpose should be to permit each well to produce that proportion of oil that will best conserve reservoir energy and lead to the largest ultimate recovery from the pool. That, in my opinion, is true conservation. That affords petroleum engineers their widest field of usefulness and affords state regulatory officials their greatest opportunity to function for the benefit of the public interest."

"Operators and state officials charged with conservation responsibilities should regard 'proration' as the efficient producing rate."

"If proration shall be based on the efficient rate of withdrawal, the matter of price is not a factor of importance, if at all, in the fair distribution of crude to be produced."

"We believe that the margin of profit to the producer can be materially improved by wider adoption of advanced producing practices."

"Producers demanding higher crude prices must admit inefficient operations. Also, higher prices place a premium on indolence and carelessness."

"Seeking a larger income from higher prices of crude and products is simply taking the easiest route for profit in the industry. The same profit can be achieved by acceptance of proven engineering principles and the application of proven practices."

"Probably what really accounts for the opposition to wider spacing is yielding of conviction on the part of the engineers or a lack of understanding and vision on the part of engineers and executives. It is an expression of a philosophy of a temporary advantage without regard for the long-range view."

"We challenge anyone, however, to refute the fact that more money will be made by all parties interested in the production of wells having a depth of six thousand feet and below (within the usual ranges of characteristics) if the wells are spaced more widely than one to 10-acres, than if the field is developed on a pattern of one well to 10-acres or less."

"The trouble with the engineering profession is that they fail to emphatically insist upon their convictions being applied. The profession of production engineers must be raised to a much higher ethical standard than heretofore."

"Engineers should * * * insist upon methods and practices being applied which they know, in the long run, will bring more profit to their employers. Engineers in the petroleum business need to develop that characteristic called 'courage', and avoid mental dishonesty. There is too much an attitude on the part of engineers and executives to put their jobs above their responsibilities. They fail to impress persistently their superiors with the facts and true situations and results. The industry needs strong men who assert and advocate their convictions regardless of personal consequences. In the end, the cowardly man in any capacity, who consistently retires to a safe position, does no good for himself or his company."

"One of the greatest problems confronting the rank and file of the industry today is to overcome the inertia of executives, proration officials, royalty owners, and stockholders with respect to universal adoption of proven scientific principles and practices. It is almost unbelievable that many companies with complete competent staffs of technical advisers consistently and arbitrarily oppose application of these practices which can only redound to their benefit."

"It is up to the engineers and technical people, working with operators and producers, to fight for the complete adoption of wider spacing and pressure maintenance. There can be no question as to the ultimate adoption of these practices, but the time element in relation to prosperity of the oil business is highly important. It appears to be a task of the technical people in the companies to insist upon the use of advanced and proven methods, not only for the preservation of professional ethics and prestige, but even in the preservation of their jobs."

"If wider spacing, unitization, and pressure maintenance were universally adopted in the oil industry, it is a perfectly safe and conservative prediction that the producers could anticipate a profit of from 10c to 20c per barrel above what can be realized today by any producer with the limited application of these improved methods. Also, by adoption of these principles, we get a stabilized situation that cannot be secured possibly by the wildly fluctuating production trends, costs, and sales prices that formerly prevailed."

« « « HIGHLIGHTS IN OILDOM » » »

Salt Water Disposal in Fitts Pool

Salt water disposal has become a problem in the Fitts Pool of Oklahoma, and to cope with it a community well is being drilled by a group of operators. It will be drilled to the Cromwell sand and will be used entirely for the purpose of disposing of salt water.

A gravity system on the east side of the pool will be employed to collect salt water and bad oil. After being treated for the removal of foreign matter, to prevent contamination of the producing sands and blocking by solids, the salt water will be boosted to the well by a pump station being erected for the purpose, the recoverable oil being sent to the pipe lines.

While experimental in part, details of the project are being worked out by engineers of the various companies involved and are being based to a large extent upon methods tried elsewhere. Full cooperation is being given by the conservation commission.

●

Gas Waste Case to Be Heard by U. S. Supreme Court

The United States Supreme Court has agreed to review decisions of a three-judge Federal Court that found the natural gas control act (passed in 1935) void and granted injunctions to two major pipe line companies against orders of the State Railroad Commission of Texas.

In appealing to the high court, the State, represented by the Railroad Commission and Attorney General William McCraw, contended that the act was a proper exercise of the police power of the state to protect a rich natural resource for the benefit of "private and public rights." It maintained that the act prevented the waste of millions of cubic feet of natural gas that formerly was allowed to escape into the air or be burned without use.

The lower court found that the State of Texas had the power to prevent waste of the gas but held the act was intended to provide a market for gas well owners who could not sell their product. This was done, it said, by forcing the major pipe line companies to reduce the production on their producing properties and buy from those who had no market.

●

Rodessa Allowables Reduced

Per well allowables in the Rodessa field of Louisiana have been reduced from 350 bbl. a day to 275 bbl., on both the Texas and Louisiana sides of the field, thus relieving to some extent the more or less unstabilizing influence that field has had on the crude market of late. The reduction in allowable was announced first by the Louisiana Conservation Commission, to be followed later by the Texas Railroad Commission. It is the first reduction of allowable for the field in four months.

The Texas Railroad Commission's order provides that all wells producing with a gas-oil ratio of 2000 cu. ft. of gas per bbl. of oil or less may produce 275 bbl. each per day. Wells having a gas-oil ratio in excess of 2000 to 1 shall produce under the displacement allowance as set forth in Rule 6 of Oil and Gas Circular No. 16-B of statewide application, which permits each well to produce 550,000 cu. ft. of gas daily and whatever volume of oil may come with that volume of gas.

Saskatchewan Oil and Gas Wells Act

An Act has been passed in the Province of Saskatchewan, Canada, governing oil and gas production. It provides for the issuance of drillers' licenses by the Minister of Natural Resources, governs drilling and inspection of wells during drilling, authorizes the issuance of regulations with respect to operation and management of wells, and provides that no person shall commence drilling operations except after the posting of a bond in amount of $5,000 in the case of a single well, or $25,000 in the case of two or more wells.

There appears to be no restriction on the right of foreigners to drill in the province, although the present Petroleum and Natural Gas Regulations of the province, issued under the Mineral Resources Act of 1931, provide that leases to mineral rights vested in the Crown may be acquired only by a company registered or licensed in Canada and having its principal place of business within His Majesty's Dominions.

●

Poland's Petroleum Laws Amended

For some time confusion has existed in Poland's petroleum industry due to compulsory governmental reduction of prices of petroleum products. So much so, in fact, that new legislation has been passed. The law of March 18, 1932, has been amended by a recent decree that makes more specific the powers of the Minister of Industry and Commerce. The decree empowers him to fix prices of petroleum products on the domestic market and to exercise his influence in rationalizing the production methods of the industry. Furthermore, the "equilization" charges that the refineries formerly were compelled to pay to a fund for financing new oil drilling may now be applied to export subsidies on petroleum products, and the Minister is empowered to establish additional funds for the promotion of drilling activities.

●

Pressure Holding Steady at Fitts

Bottom-hole pressure has been holding unusually steady in the Fitts Pool of Oklahoma, a test just completed of key wells reveals. The overall average pressure for the area declined from 1333.24 lb. on May 2 to 1320.47 lb. on June 2, a loss of but 12.77 lb., or a loss of 0.00805 lb. per 1000 bbl. of oil.

●

Government's Title to Elk Hills Oil Land Reaffirmed

Secretary of the Interior Harold L. Ickes has reaffirmed his ruling of January 24, 1935, that the United States Government has a just title to Section 36 in the Elk Hills, California, area. The latest ruling was made in denying a motion for rehearing of the case brought by the State of California and other interested parties, principally major oil producing companies. Those asking the rehearing based their rights on an alleged title acquired by the State of California in 1903 under the school-land grant act.

The 1935 decision, in addition to upholding the right of the United States to title and control of Section 36, also gave the government legal basis for requiring the claimants to account for 5,500,000 bbl. of oil and 57,000,000,000 cu. ft. of gas that already had been produced from the disputed area.

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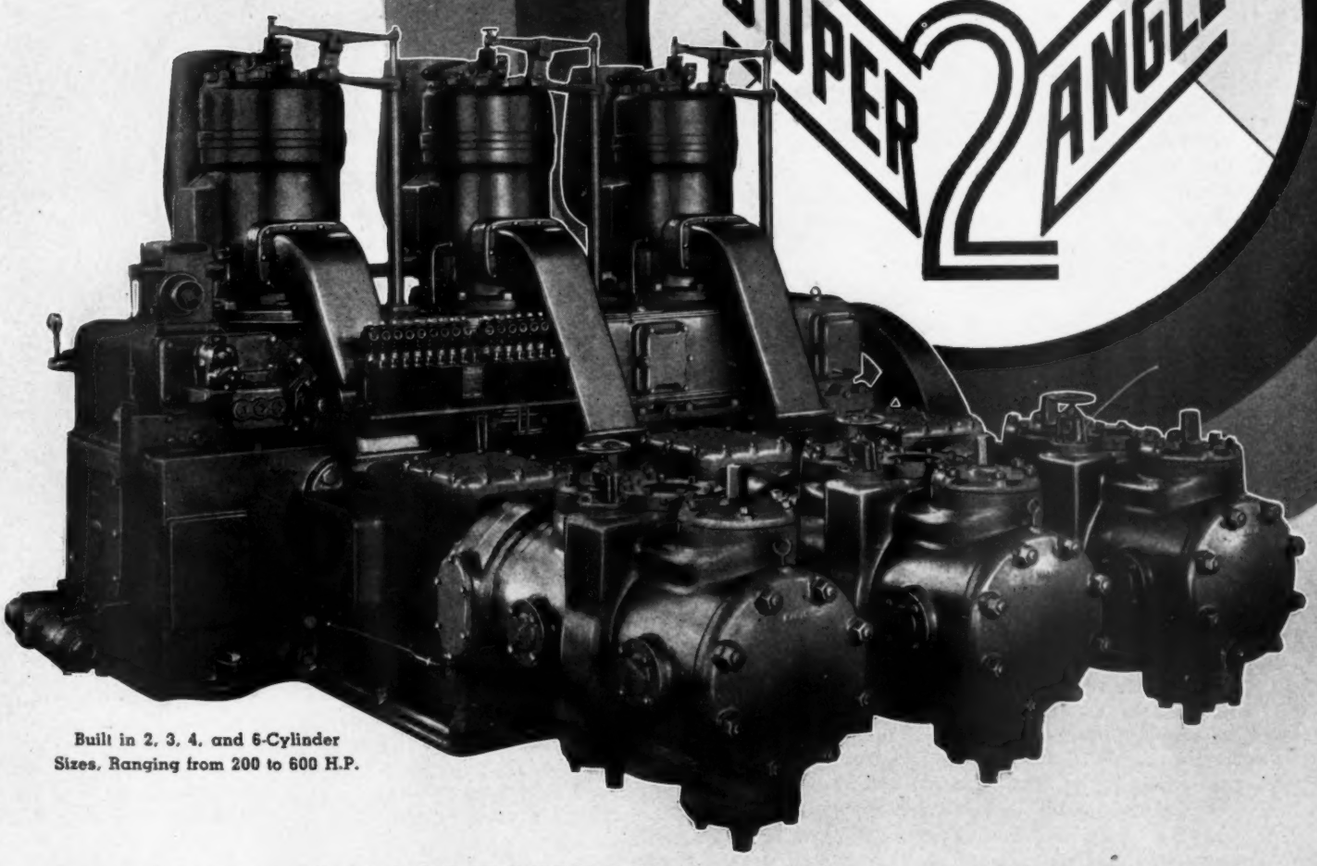

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PROGRESS OF MAJOR PIPE LINE WORK

THE Texas-Empire Pipe Line Company will spend $4,500,000 to increase its pipe line facilities to Chicago, it has been announced. The program contemplates the construction of a new 10-in. line from Sheldon, Missouri, to Boyer Station, Valley Center, Kansas, a distance of 143 miles, as well as the laying of 185 miles of 12-in. loops between Sheldon and Heyworth, Illinois. The loops will increase the capacity of the line from 70,000 bbl. daily to 90,000 barrels. The capacity of the Sheldon-Boyer line will be 20,000 barrels. Work will start at once with completion by October.

•

The White Eagle Division of the Socony-Vacuum Oil Company, Inc., will lay a 6-in. pipe line from its refinery at Augusta, Kansas, to Kansas City, Kansas, via Topeka, Kansas, a distance of 178 miles, it is announced by R. R. Irwin, president. When the present government project for making the Missouri River navigable as far as Sioux City, Iowa, is completed, the gasoline can be shipped to northern points by barge at low cost, Mr. Irwin says in making his announcement.

•

The 230-miles 22-in. pipe line being laid by the Michigan Gas Transmission Company, subsidiary of the Columbia Gas and Electric Company, from Zionville, Indiana, to Detroit, Michigan, is expected to be completed by August. At Zionville a 5000-hp. station is being constructed. It is at this point that the line ties into the main line of the Panhandle Eastern Pipe Line Company.

To take care of the added load when the line between Zionville and Detroit is finished, the Panhandle Eastern is now erecting a compressor station at Haven, Kansas, which is expected to be completed by September 1st. The station will have three 1300-hp. twin gas-engine-driven compressors. The contract for the station was given to the Fluor Corporation, Los Angeles, California. It will cost approximately $500,000 to construct. Other stations are to be erected later at the following points: near Greensburg, Kansas, with three 1300-hp. compressor units; Olpe, Lyons County, Kansas, with four 1300-hp. compressor units; Centralia, Missouri, with four 1300-hp. units; and at Louisiana, Missouri, where the line crosses the Mississippi River. At Liberal, Kansas, two 1000-hp. units will be added to the existing equipment of the station.

•

The Home Oil and Refining Company, of which C. W. Rice is president, plans to construct a 6-in. pipe line 100 miles in length to serve three of Montana's major fields; namely, Cut Bank, Pondera, and Kevin-Sunburst. The cost of the line is estimated to be approximately $675,000.

Four pumping stations will be erected, two between Cut Bank and Conrad, and two between Conrad and Great Falls. The capacity of the line will be 6000 bbl. per day, although the volume normally pumped is expected to be about 3000 barrels.

The route of the line will be from Cut Bank to Great Falls. A line from Kevin-Sunburst will connect near Shelby. A line from Pondera will tie in at Conrad. At Cut Bank a connection will be made with a private line being constructed to serve leases of Nadeau Brothers, and Cobb and Pardee. In addition, 20 miles of gathering line will be laid.

•

The Keystone Pipe Line Company, subsidiary of the Atlantic Refining Company, is laying a 57-mile 8-in. loop to its gasoline line from the refinery near Philadelphia to Pittsburgh. The loop will increase materially the capacity of the line. This work is expected to be completed about July 1st. The Marathon Construction Corporation, Dallas, Texas, is the contractor. The line is being laid on a separate right-of-way a short distance from the old line. Equipment will be added to the booster stations at Montello, Quentin, and Mechanicsburg.

•

The Baird Refining Company plans to construct a 4-in. oil line from its refinery at Chautauqua, near Baird, Texas, to the Hawley field, a distance of 27 miles. The purpose of laying the line is to supply the plant with much needed crude. At present the company is purchasing Jones County crude delivered by tank truck to supplement the supply available from the shallow area of Callahan County.

•

The Humble Pipe Line Company is planning a 20-mile extension to its Harbor Island line. It will run from the present terminus in the Tom O'Connor field, Refugio County, Texas, to Heyser, Calhoun County, and from the latter point the line likely will be extended to production in the Placedo field, Victoria County.

•

The Apex Construction Company is laying two 3-in. lines for the Barnsdall Pipe Line Company from the Placedo field to Port Lavaca, Texas, a distance of 13 miles.

•

A 10-mile 6-in. loop to its trunk line extending north of the Grand Falls district of Ward County, Texas, is being laid by the Atlantic Pipe Line Company. The capacity of the line will thus be increased from 16,000 bbl. daily to 25,000 barrels.

•

The Kansas Corporation Commission has granted authority to the Kansas Pipe Line and Gas Company to construct a gas line from Rush County, Kansas, into Nebraska. The line will originate in the gas field near Otis and will serve a number of towns in Nebraska. At a later date it is announced that the line will be extended to supply cities in northwestern Kansas.

•

The Independent Pipe Line Company, of which E. G. Germany, Dallas, Texas, is president, is to lay a gathering system in the new Talco pool of northeast Franklin County and northwest Titus County, Texas. Harold Byrd and Jack Frost, of Byrd-Frost, Inc., Dallas, are interested in the project with Mr. Germany. A 10-car loading rack is being erected southeast of Talco and the gathering system will tie into this.

Multi-Flame Lindewelding

On this 8-in. pipe line for crude oil service metallurgically sound welds are assured by Multi-Flame Lindewelding.

makes Pipe Line Joints *leakproof forever*

THE Multi-Flame Lindeweld embodies these four inherent features which promote high-efficiency joints:

Strength. Lindewelds consistently develop the full strength of line pipe—65,000 lb. to 75,000 lb. per sq. in. Even on base material having a tensile strength, as high as 110,000 lb. per sq. in. the Lindeweld is as strong as the parent metal.

Ductility. The multi-flame preheats the base metal before and post-heats the weld after welding, thus making the Lindeweld unusually ductile.

Corrosion Resistance. The ability of oxy-acetylene welds to resist rust and pitting so often revealed during the reconditioning of old lines is fully developed in the Multi-Flame Lindeweld.

Density. The weld deposit from Oxweld No. 24 Lindeweld Process Welding Rod is homogeneous, dense, and defect-free.

This new technique of welding thus assures the satisfactory performance of a pipe line. At the same time it doubles or triples the daily production of sound welded joints and saves 15 to 40 per cent in oxygen, acetylene and welding rod consumed.

Linde Service Operators because of long experience in the pipe line field can help you take full advantage of this economical construction method. Linde Offices will gladly supply complete information and arrange a showing of the new motion picture on Multi-Flame Lindewelding for your organization. The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, New York and principal cities.

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LATEST ACTIVITIES IN THE OIL FIELDS

THE Shell Oil Company's and the Ohio Oil Company's wildcat well, No. 1 K.C.L., successfully completed 12 miles west of Bakersfield, California, is said by officials of the two companies to give promise of being one of the most important oil discoveries since the bringing in of the Kettleman Hills field. The well flowed initially at the rate of 16,000,000 cu. ft. of gas daily, together with an undetermined volume of oil. The well was drilled to a total depth of 7888 ft., and the producing sand is approximately 80 ft. in thickness.

●

The Gulf Coast area of Texas continues in the spotlight, a new pool having been opened in Calhoun County. No. 2 R. H. Welder of the Humble Oil and Refining Company and the Plymouth Oil Company, two miles north of Heyser, upon completion flowed 157 bbl. on a 24-hour test through 7/64-in. choke. The well was drilled to a total depth of 5474 feet. The oil is 33.8 gravity.

●

Maintaining its record in the matter of new pools, the State of Kansas recently has seen several new ones added to its already large list. The Empire Oil and Gas Company's No. 1 Cunningham in McPherson County, two miles east and four miles north of Canton, found production in the Mississippi lime at a total depth of 2832 feet. A new field also has been opened in Ness County by the Continental Oil Company with their No. 1 Thompson. It swabbed 139 bbl. of crude in six hours from a depth of 4462 feet. Ellis County also is the scene of a new strike, No. 1 Walter of Reynolds et al, ten miles north and slightly east of Hays, was treated with acid at a depth of 3165 ft. and pumped 1159 bbl. of 40-gravity crude in a 24-hour period.

●

Discovering a new pool for Ector County, Texas, No. 1 Cummins of William H. Dunning, Jr., has been successfully completed four and one-half miles northwest of the Goldsmith field. From a total depth of 4252 ft. it flowed 406 bbl. by heads in a 24-hour period.

The Montana-Dakota Utilities Company has opened a new field in Montana with its No. 1 Unit. The well, on the Little Beaver Dome, Fallon County, made an initial flow at the rate of 3300 bbl. per day through 2½-in. tubing on a test lasting an hour and a half. On a later test through tubing and a 6⅝-in. production string it flowed at the rate of 7560 bbl. per day. The well is drilled to a total depth of 6739 feet.

●

One of the best producing wells yet completed in the Fifth sand streak of southwest Pennsylvania has been brought in by the Union Gasoline and Oil Corporation in Amwell Township, Washington County. The well flowed 170 bbl. the first day, declined to 115 bbl. the second day, and to 85 bbl. the third.

●

A deep sand pool has been opened in Caddo County, Oklahoma, by the Marathon Oil Company with their No. 4 Marchand. The well is in the southeastern part of the county and flowed 442 bbl. of oil in nine hours on the initial test, together with an estimated gas production of 50,000,000 cu. ft. Total depth of the well is 6367 feet.

●

A new pool has been discovered in Grant Township, Huron County, Michigan, near Bad Axe, approximately 50 miles east of the Porter field. The discovery well is Wallace Markle's No. 1 Frank Opaka. Production is from the Dundee formation at the rate of 200 bbl. per day. Total depth is 3007 feet.

●

Southern Colorado was given its largest well to date with the successful completion of No. 6 Gramps by the William E. Hughes Estate in Archuleta County. The well swabbed at the rate of 1448 bbl. in 24 hours.

●

A wet gas field has been found in Webster Parish, Louisiana, by J. P. Evans with his No. 1 Crichton. At a total depth of 5589 ft. the well tested 26,700,000 cu. ft. daily.

AVERAGE CRUDE PRICES

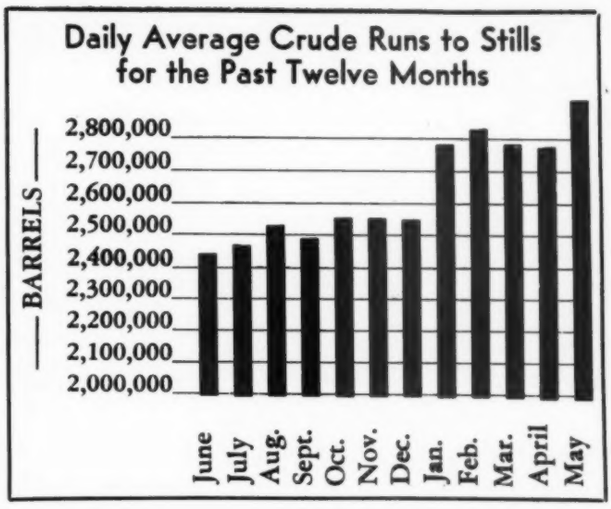
California	
Kettleman Hills	$1.22-1.43
Playa Del Rey	1.10
Coalinga	.70-.90
Signal Hill	1.10
Montana	1.45
Wyoming	1.10
Colorado	1.00-1.10
New Mexico	.75-.95
Texas	
North Central	.84-1.08
Panhandle	.81-.98
West Texas	.75-.95
Gulf Coast	.85-1.30
Darst Creek	.88-1.22
East Texas	1.15
Kansas	1.10
Oklahoma	1.10
Arkansas	.75-.80
Louisiana	
Gulf Coast	.82-1.22
North Louisiana	$ .86-$1.10
Illinois	1.23
Kentucky	1.23
Indiana	1.12
Ohio	
Lima	1.25
Michigan	1.12
Pennsylvania	
Bradford	2.45
Southwest	2.17
Eureka	2.12
Buckeye	1.97
Corning	1.42
West Virginia	1.67
Canada	2.10-2.17

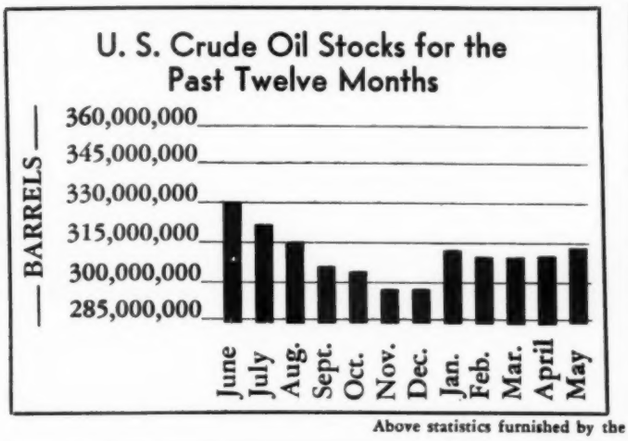
DAILY CRUDE OIL PRODUCTION

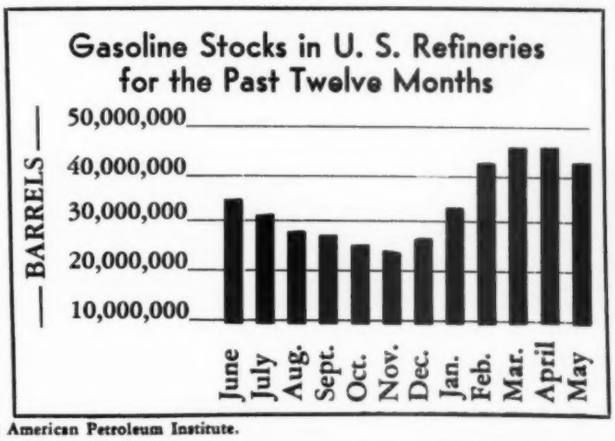
Supplied by A.P.I.

(Figures in Barrels)

	B. of M. Dept. of Interior Calculations (May)	Week Ended May 30, 1936	Week Ended April 25, 1936	Week Ended June 1, 1935
Oklahoma	538,300	531,600	557,100	494,800
Kansas	150,100	155,300	159,100	153,200
Panhandle Texas	.....	62,450	64,000	62,550
North Texas	.....	58,850	59,450	58,800
West Central Texas	.....	25,450	25,000	25,750
West Texas	.....	177,700	180,800	151,100
East Central Texas	.....	51,850	50,850	47,400
East Texas	.....	435,650	447,400	453,000
Southwest Texas	.....	81,950	79,450	59,050
Coastal Texas	.....	251,850	248,850	178,450
TOTAL TEXAS	1,132,500	1,145,750	1,155,800	1,036,100
North Louisiana	.....	84,600	68,300	23,200
Coastal Louisiana	.....	148,650	145,700	115,950
TOTAL LOUISIANA	170,500	233,250	214,000	139,150
Arkansas	31,000	29,850	29,850	31,200
Eastern	102,900	114,600	102,400	109,600
Michigan	38,200	32,950	32,300	40,350
Wyoming	35,600	36,150	34,900	35,150
Montana	12,900	17,050	10,350	10,250
Colorado	4,400	4,600	5,100	3,900
New Mexico	65,900	74,850	63,400	51,000
TOTAL EAST OF CALIF.	2,282,300	2,375,950	2,364,300	2,104,700
California	544,000	568,000	568,400	471,200
TOTAL U. S.	2,826,300	2,943,950	2,932,700	2,575,900







Above statistics furnished by the American Petroleum Institute.

Summarized Operations in Active Fields for May, 1936

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	310	303	80	118	3600	2	40	Rotary
Duval County	144	126	33	52	2300	2	22	Rotary
Archer County	59	32	18	41	660–1800	1 or 2	40	Rot.-Cab.
Conroe	6	5	1	3	2000–7400	3 or 4	40	Rotary
Panhandle	76	71	40	161	2200–3900	2	40	Rotary
Refugio County	6	6	2	6	5200	2	38	Rotary
Oklahoma								
Oklahoma County	12	11	41	170	6500	3	39	Rotary
Pontotoc County	47	42	22	96	1800–4488	2 or 3	38	Rotary
Osage County	30	23	14	44	380–2850	2	37.5–40	Rot.-Cab.
Kansas								
McPherson County	6	5	2	6	2900–4300	2	38	Rot.-Cab.
Harvey County	4	2	2	3	3450	2 or 4	37	Rot.-Cab.
Ellsworth Arch	122	92	43	141	3300	4	37	Rot.-Cab.
Louisiana								
Rodessa	49	49	12	66	5985–6450	3	39	Rotary
California								
Kettleman Hills	7	7	9	39	8300	3 or 4	40	Rotary
Long Beach	1	0	3	8	7000	3	36	Rotary

Field Activities by States for May, 1936

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1935 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	7	4	1	2	21	10	13	10	41	39	11,140,750
California	61	59	56	47	133	107	104	86	288	234	207,899,480
Colorado	....	3	....	1	....	....	5	4	29	26	1,565,150
Illinois	....	....	....	....	....	....	22	23	8	7	4,352,000
Indiana	9	27	4	13	....	....	6	5	71	67	762,000
Kansas	173	125	122	98	210	190	67	61	356	326	53,013,450
Kentucky	54	22	29	11	....	....	8	7	19	17	4,860,000
Louisiana	131	83	106	63	133	128	70	68	238	232	50,299,950
Michigan	81	49	59	33	96	50	85	80	131	121	15,661,350
Mississippi	1	....	0	....	....	....	1	1	9	10	Gas. Prod.
Montana	16	11	15	10	....	....	13	11	67	64	4,304,100
New Mexico	65	40	59	40	....	....	21	17	123	118	19,195,500
New York	....	....	....	....	....	....	1	1	2	2	3,191,900
Ohio	169	156	131	108	....	....	46	43	184	178	4,234,000
Oklahoma	267	220	197	153	325	384	92	86	744	696	181,152,050
Pennsylvania	....	....	....	....	....	....	13	14	119	109	14,478,000
Texas	1355	1025	1048	810	1694	1338	673	587	1925	1667	377,747,205
West Virginia	67	86	58	77	....	....	39	35	136	126	3,818,400
Wyoming	4	4	0	4	....	....	15	11	81	73	13,390,100
Totals	2460	1914	1885	1470	2575	2207	1294	1150	4571	4112	970,995,385

THE MONTH'S ACTIVITIES IN REFINING

Percent Refinery Capacity Operated

Western Division, 73.8 percent **Central Division, 76.7 percent** **Eastern Division, 81.2 percent**

THE Atlantic Refining Company's 18,000-bbl. refinery at Atreco, Texas, is now under construction and will be completed some time before the end of the year. The Atlantic is spending $5,000,000 on the plant, it is understood. Upon completion of this refinery, the plant at Brunswick, Georgia, may be partially or wholly shut down, except as a storage terminal.

●

A new plant of the State Oil Shale Industry, Estonia, is nearing completion and will have an annual capacity of 16,000 tons of crude oil. The company now has a plant in operation of 12,000-ton capacity, and the cracking equipment of this unit will be increased to an annual capacity of 2500 tons of gasoline.

The Estonian Oil Consortium, owned by Swedish interests, is repairing its plant and will have it in operation shortly. The firm also is preparing to open oil shale mines. The capacity of the remodelled plant will be 12,000 tons of crude and 2,000 tons of gasoline per annum.

When these new and improved plants are put into operation, the total capacity of the Estonian refining industry will be increased to approximately 120,000 tons of crude and 15,500 tons of gasoline yearly.

●

In writing, in the May issue of *The Petroleum Engineer*, of the construction program being initiated at its refinery by the Kendall Refining Company, the address was given erroneously as Oil City, Pennsylvania. As is well known, the Kendall refinery is at Bradford, Pennsylvania. In calling attention to the error, H. H. Greene, executive vice-president, writes in part as follows: "For 54 years the Kendall Refining Company has engaged in the refining of 100 percent Bradford Grade of Pennsylvania crude oil, and during that period of time its refinery has always been in 'The High Grade Oil Metropolis of the World'—Bradford, Pennsylvania."

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ended May 30, 1936
A.P.I. Figures
(Figures in Barrels of 42 Gallons Each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	519,000	84.8	19,663	8,654
Appalachian	94.8	103,000	70.5	2,600	505
Ind., Ill., Ky.	95.9	375,000	88.4	10,571	3,547
Okla., Kans., Mo.	84.8	298,000	77.€	7,334	2,932
Inland Texas	48.5	111,000	69.4	1,584	1,696
Texas Gulf	96.8	620,000	94.2	7,692	7,072
La. Gulf	96.4	121,000	74.2	1,469	2,009
No. La.-Ark.	90.0	49,000	68.1	445	401
Rocky Mt.	61.9	50,000	83.3	1,508	753
California	92.6	508,000	64.4	13,376	71,678
Reported	89.6	2,754,000	79.4	66,242	99,247
Est'd. Unreported	.....	181,000	.....	4,868	2,271
*EST'D TOTAL U. S. May 30, '36	.....	2,935,000	.....	71,110	101,518
*EST'D TOTAL U.S. May 23, '36	.....	2,975,000	.....	72,490	100,212
U. S. B. of M. May, 1935	.....	2,594,000	.....	**61,483	**100,177

*Bureau of Mines basis currently estimated.
**As of May 31, 1935.

A skimming plant of 1500-bbl. capacity is being erected at Alma, Michigan, by the Northern Refineries, Inc. E. G. Guy is in charge of the construction work. Officials of the company are as follows: J. H. Frichet, president; D. M. McCuiag, vice-president; and F. C. Mapes, secretary-treasurer.

Another plant to be constructed soon in Michigan will be that of the Petroleum Chemicals Company, Inc., at Grand Haven. The contract for construction of the plant has been awarded to Hurley Brothers, of Tulsa, Oklahoma, and will be according to plans and specifications prepared by Gerald W. Wagner, consulting engineer, Grand Rapids.

●

According to a recent announcement, the National Refining Company will install a new atmospheric vacuum distillation unit at its Findlay, Ohio, refinery. This will virtually double the capacity of the plant, which at present has a crude capacity of 3200 bbl. and a cracking capacity of 1350 bbl., per day.

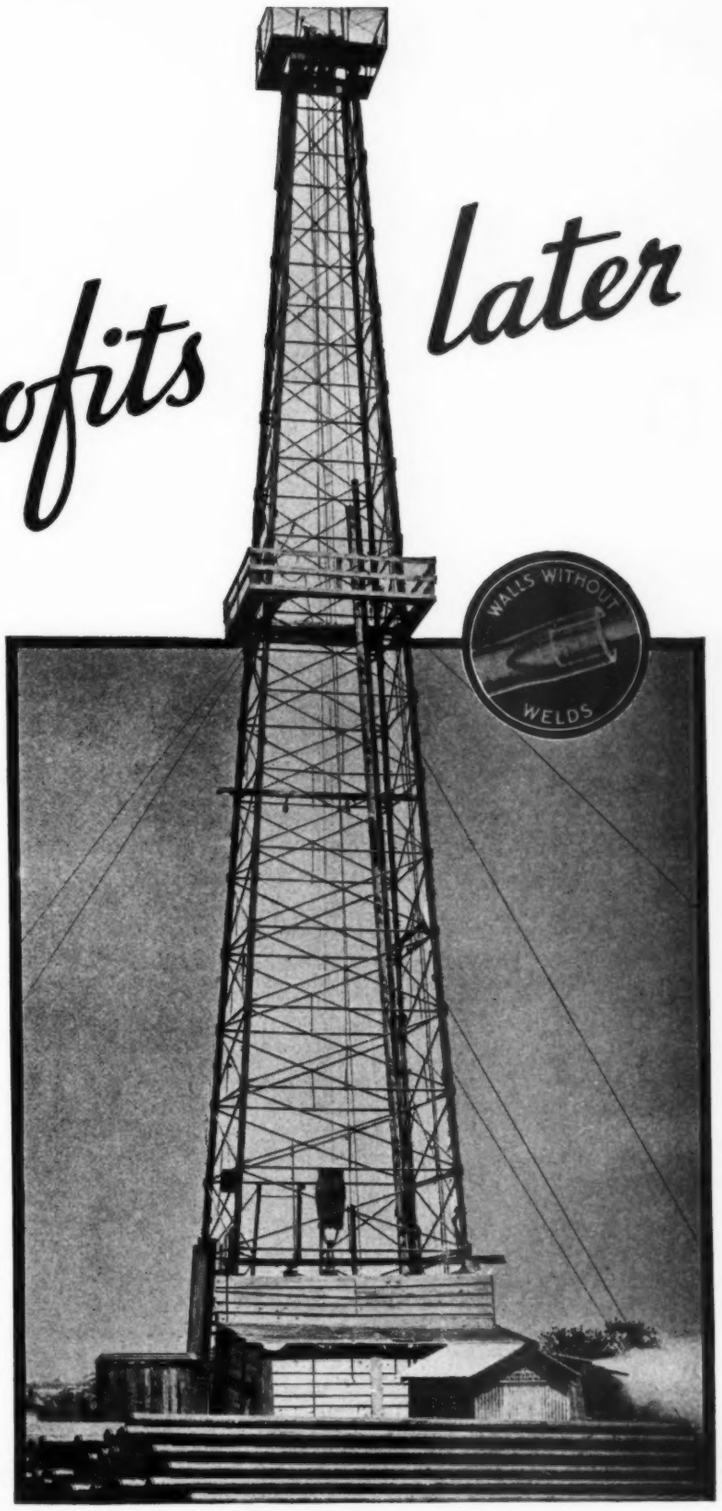
●

Petroleos de Mexico, S. A. (Petromex) a company controlled by the Mexican government, has signed a Dubbs license contract and will build a Dubbs 2-coil selective cracking unit in its refinery at Tampico. The refinery now has a crude capacity of 3000 bbl. per day and the Dubbs unit is to crack 1100 bbl. a day. Petromex will build the unit under the supervision of Universal engineers.

The new construction program will include treating and rerunning equipment. Considerable of the materials used will be purchased in Mexico.

The plant operates on crude from the Poza Rica and the Panuco fields. In addition to producing gasoline, the Dubbs cracking unit will manufacture fuel oil for the Mexican National Railways.

PLANT IT NOW *for profits later*



CASING costs show up after the first year or so. If it can withstand unusually severe strains and shocks that are frequently encountered in running and cementing, and still remain sound and trustworthy over a period of years — then it will be profitable casing. Extra expense in later years can more than wipe out the savings made by using cheaper material. As production decreases, production costs increase, hence freedom from replacements and repairs means important economies.

Experienced operators know every tough hazard that casing has to face, and they've seen how well NATIONAL Seamless comes through. They know it stabs easily, screws together smoothly and accurately. They know it will not split at a weld a thousand feet or more down — *it has no welds.*

Briefly, old hands in the oil fields depend on NATIONAL Seamless A. P. I. Diamond BX and B8 Casing for soundness, durability and uniformity worthy of their confidence. Get the habit and specify NATIONAL Seamless for your wells.

National
Seamless Casing

NATIONAL TUBE COMPANY

PITTSBURGH, PA.

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

Fig. 1. One of the drill pipe twist-offs observed

By

K. C. SCLATER

Drill Stem Troubles in Oklahoma City Field Extension

Increasing the speed of rotation without restraining the weight on bit is a direct cause of twist-offs—a better understanding of the close relation between bit pressure and rotating speed would lead to their stricter control during drilling and result ultimately in longer life of drill pipe, lower drilling costs, and improved drilling speeds.

DRILLING operations in the Capitol extension of the Oklahoma City field are being carried on at a feverish pace. There is some doubt whether under such competitive conditions normal discretion always is exercised in regard to following safe and sound drilling practices. Particularly evident is the prevalence of drill stem trouble with which the field recently seems to have become afflicted. This trouble has to do chiefly with the bending of drill pipe and injury to tool joints. Not all drilling contractors are having difficulties, but the trouble is general enough that interest has been aroused regarding its cause and how it might be reduced or eliminated.

In order that the problem could be frankly and constructively discussed, drilling contractors, tool pushers, superintendents, and representatives of the manufacturers of drill pipe and tool joints were brought together at a meeting held in the Biltmore Hotel on the evening of June 3rd. Out of the open discussion and frank opinions offered some constructive course of action it is hoped will develop toward mitigating the trouble.

Trouble of this kind affects the drilling contractor because he is faced with serious losses resulting from his having to retire drill pipe from service much earlier than anticipated; the producing company is confronted with indirect losses arising from possible delays and probable interference with the proper completion of the well; the manufacturers of drill pipe and tool joints have a vital interest in finding out where the trouble lies—they are vitally concerned in seeing that equipment is adequate to meeting the demands for service placed upon it in the field.

What follows are observations made by the writer as the result of a recent trip to the field and attendance at the meeting mentioned.

General practice in the field is to set and cement approximately 1000 ft. of 13⅜-in. surface casing, for which an 11-in. or 12¼-in. hole is drilled and then

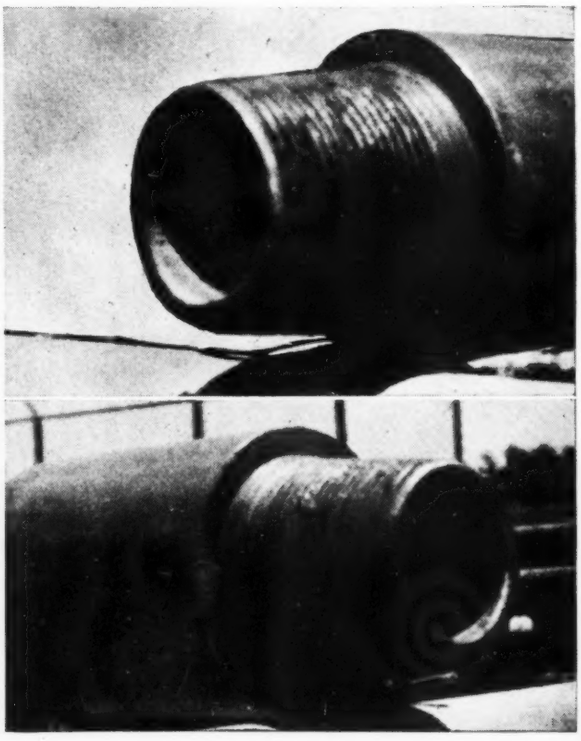


Fig. 2. Joints accumulate a thick layer of dirt on the rack

Fig. 3. Erosion by leakage at the joint threads—an incipient twist-off

reamed to 17 inches. Drilling is then carried on to the top of the Wilcox sand at 6300-6400 ft. and casing (usually 8⅝-in. or 9⅝-in.) set and cemented (using 1500 to 2000 sacks cement) at this point. Practically all drilling is done with rock-bits on 6-in., 25.20-lb., A.P.I. Grade D, drill pipe.

It appears that most of the trouble with bent drill pipe is encountered in the upper part of the hole, while drilling below the surface casing at a depth of 1500 to 1800 ft. from the surface. On one well, the drill pipe was bent so badly that it was laid on the rack and retired when a depth of 4000 ft. had been reached. Several twist-offs had occurred, resulting in five fishing jobs. Two joints of drill pipe were found that were partially twisted off; there was leakage through the pipe at the last few threads and out through the counterbore of the tool joint pipe threads. The first twist-off in this string of drill pipe occurred at a depth of 700 ft. from the surface while drilling at 2500 feet. Some of the bent joints were as much as 4½-in. off center and most were 3½-in. off center when rotated. Another drilling contractor in the field had experienced similar trouble and damaged several hundred feet of drill pipe. He was successful in overcoming his trouble by using oversize (10¾-in. O.D.) rubber stabilizers on the drill pipe. There are many other instances of trouble similar to the foregoing having been encountered, although not quite so severe.

It was learned that in one well the lower joints of surface casing had broken off and slipped down the hole. What happened in this case can only be conjectured; possibly excessive whip of the drill pipe in the casing was partly if not wholly the contributing cause.

Among the more conservative and careful drilling contractors in the field it is estimated that in the Oklahoma City field extension the average life of a string of drill pipe is three or four wells, or approximately 24,000 ft. of hole. There are other drilling contractors, among them those that have had considerable trouble, who get an average life of only one or two wells per string of drill pipe, or approximately 10,000-12,000 ft. of hole. Assuming $20,000 to be the average cost of a string of drill pipe, it can be seen that the drill pipe cost per well is quite high, and also quite variable. At four wells per string of drill the average cost for drill pipe is $5,000 per well and at 1½ to two wells, $13,000 to $10,000 per well.

A wide variation in practice exists in the field with regard to weight carried on the bit and speed of rotation. Bit pressures carried range from five points up to 25 points (12,000 to 65,000 lb.) on the weight indicator; and average rotating speeds from 65 to 125 r.p.m.

In the haste to make hole the pressure on the bit is, in many cases, increased beyond safe limits for the rotating speed employed. When drilling in large straight hole, too much weight on the bit flexes the pipe and causes it to whip against the wall of the hole. If the speed of rotation is very great, bending and torsional stresses are set up in the drill pipe, the combination of which eventually causes the pipe to give way at the thread; also the inertia of rotation of a heavy string of drill pipe at high speeds will put a permanent kink or bend in the pipe. Experience in other fields indicates that in a crooked hole, twist-off troubles are not so prevalent as might be imagined even where heavy bit pressure and high rotating speed are employed. The explanation is that the rotating drill pipe is restrained from whipping by the wall of the hole. Similar reasoning applies to drilling in a tight hole, where the wall of the hole forms a good support for the drill pipe and thus restrains the bending action during rotation.

Most of the trouble with drill pipe in the Capitol field has occurred in the upper part of the hole while drilling with most of the drill stem in the casing.

In the early development of the Oklahoma City field proper, it took 120 days to complete a well. Drilling was gradually speeded up with the further development of the field until it took but 80 days to complete a well. Contrast this drilling speed with that in the Capitol extension of the field, the development of which began only several months ago, when it took 60 days to complete a well. Today the drilling time on many wells is from 30 to 35 days, and this includes fishing jobs. This is a tremendous increase in drilling speed and a fact that cannot be overlooked.

Another fact to be noted is that the appearance of this trouble has been rather sudden and is coincident with the beginning of highly competitive drilling operations in the Capitol extension of the

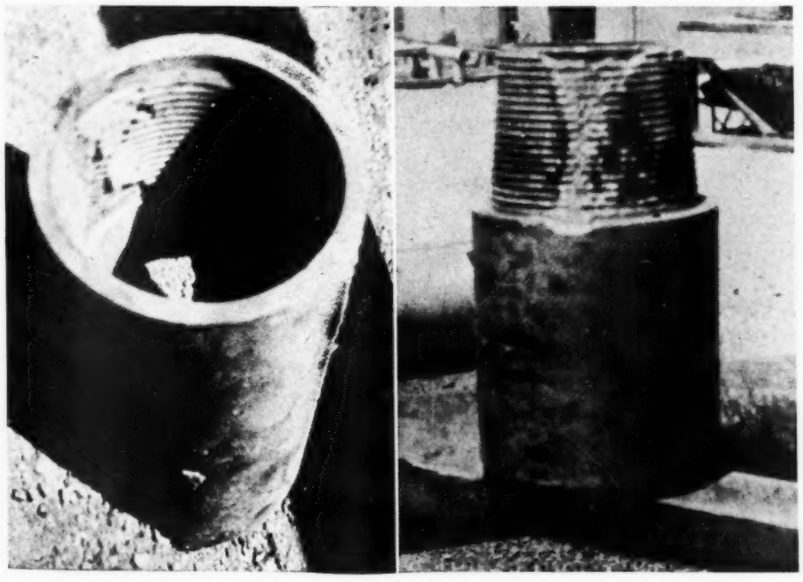


Fig. 4. Erosion of threads on male and female end of joint by "washing-out".

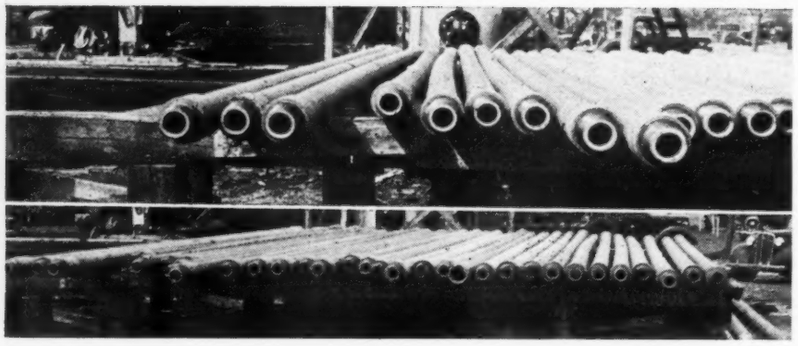


Fig. 5. Some examples of bent drill pipe pulled from a well now drilling near the Capitol.

Oklahoma City field. This supports the belief that the real root of the trouble is the hectic urge for greater footage and more rapid completions. Tremendous improvements both in material and manufacture have been made in drill pipe and tool joints in recent years, yet despite this fact there suddenly appears overnight trouble with drill pipe and tool joints. One inference can be drawn: abnormal demands are being made on drill pipe that are out of all proportion to what is deemed reasonable and safe.

It does not seem to be fully appreciated that there is a definite relation between bit pressure and rotating speed. One is a function of the other. To talk of one without the other in drilling operations is meaningless. The use of higher speeds without a reduction in bit pressure usually will lead to trouble. It may well be asked, what is the effective weight to be carried on the bit for a given rotating speed? This was the query put by one of the drilling contractors in the Oklahoma City field extension when he inquired if a chart were available showing the effective weight that should be carried on the bit for a given rotating speed. So far as the writer is aware there is none. At the present time this is determined only by experience. Outside of his own experience in drilling different types of formations, the drilling contractor has very little to guide him. Little or no accurate information is available on the proper bit pressure to carry for a given rotating speed. Such information, if available, would be an invaluable aid to the driller and an effective means of reducing or entirely eliminating drill pipe troubles of the type now being encountered.

When the drill pipe is bent, injury to the tool joint ensues. It already has been pointed out what happens in the hole due to leakage at the tool joint. Obviously, there also is injury done to the tool joint threads when running in or pulling out bent drill pipe.

There have been several bad cases of "washing out" at the tool joints. One prolific source of trouble is improper care of joints in the field. Care should be taken to clean the threads thoroughly before making up joints. When drill pipe or tool joints lie on the rack for any length of time they accumulate a thick layer of sand and gritty material that is sometimes quite difficult to remove. Unless threads are thoroughly cleaned they become galled and will not make-up properly; as a result the joint will leak, "wash-out" at the threads, and end eventually in a twist-off.

Another source of tool joint trouble is the method of making-up joints. The cathead man on making the final turn with the rope before tonging, will make the joint "smoke," thus injuring the threads.

Some drilling contractors in the field employing a bit pressure of 15 to 25 points (35,000 to 65,000 lb.) and a rotating speed of 125 r.p.m. have to lay down or retire an average of 75 joints of drill pipe per well. It is estimated that for the wells drilled by this group fishing jobs average six per well. Most of the fishing jobs occur at the seventh or eighth joint from the top of the drilling string.

One well in the field was drilled from the bottom of surface pipe to the top of the Wilcox sand in 27 days,

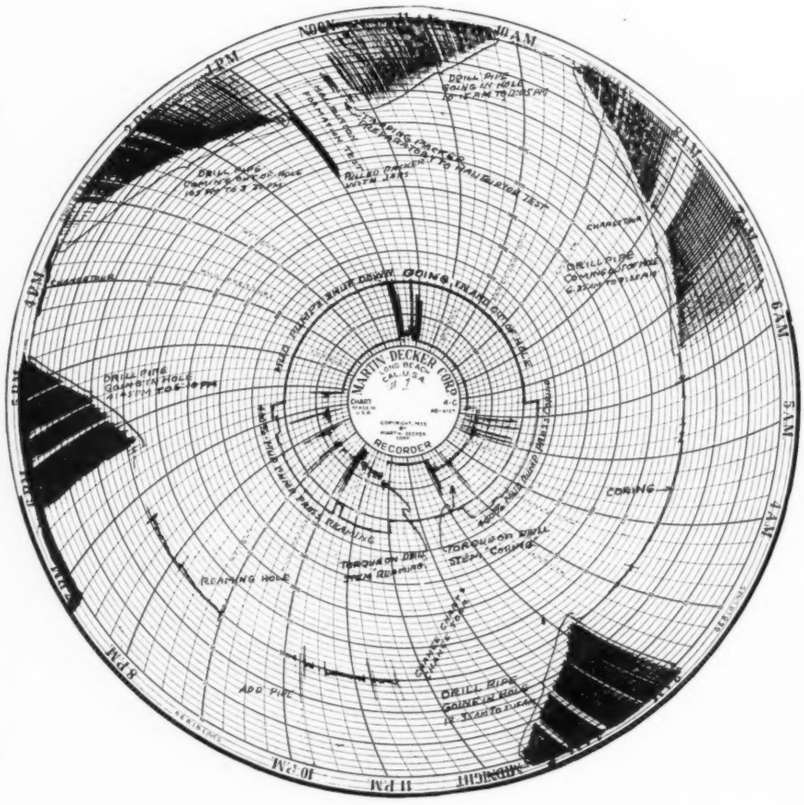


Fig. 6. A complete daily record of operations obtained on a drilling well.

employing 7 to 8 points (17,000 to 19,500 lb.) bit pressure and 100 r.p.m. rotating speed, and experienced no trouble. A moderate bit pressure of from 12,000 to 14,000 lb. and a rotating speed not exceeding 80 r.p.m. is used by some drilling contractors who experience no trouble yet obtain a good average drilling speed. At a number of drilling wells visited it was observed, however, that the rotating speed was in excess of 100 r.p.m. and that a pressure of as high as 18 points (45,000 lb.) was carried on the bit while drilling. This gave the impression that the idea is prevalent among drillers that in order to make hole excessive weight must be carried on the bit and the speed of rotation increased. Perhaps it is not realized that in doing so they actually are attempting to improve drilling speed at the expense of not only higher drill pipe costs but also the grave risk of drill stem failure and subsequent fishing difficulties.

Records of drilling wells in other fields show that much lower bit pressures are employed than those now being used in the Capitol extension of the Oklahoma City field. One successful drilling contractor in Kettleman Hills drills with a rotating speed of 250 r.p.m. and never allows the bit pressure to exceed two points (5000 lb.).

All the evidence points to the probability that drill stem trouble in the Capitol extension of the Oklahoma Cty field is the result of excessive bit pressure and high speeds of rotation. This is aggravated by drilling in a large hole. Such also is the general opinion expressed by many drilling contractors, tool pushers, and superintendents in the field. The cause of the trouble suggests the remedy; that is, maintenance of moderate bit pressure and reasonable speed of rotation.

It has been urged as an aid in applying the remedy that a tangible record be kept of what goes on at the well every minute of the day, in particular, the weight on the bit, the torque on the drill stem, and the mud pump pressure. Most drilling contractors and tool pushers are thoroughly aware of the advantages of the handling of drill pipe and go to great lengths instructing their drilling crews. But the fact remains that they cannot always be sure that their orders are being carried out. A most valuable aid in such cases is a 24-hr. record showing clearly drilling operations at the well.

Such a record is shown in Fig. 6. This chart was taken from a well drilling at a depth of 7300 ft. with 4½-in. drill pipe and using eight lines. While the hole was being reamed from 6:20 p.m. to 11:40 p.m. very little weight (less than 7000 lb.) was carried on the drill stem and an almost uniform torque of only 25 lb. was carried on the drill stem. Similarly, from 2:15 a.m. to 6:20 a.m. while coring and drilling, a bit pressure of less than two points (5000 lb.) and a torque of 20 lb. on the drill stem were held almost constant, except when the drill pipe was picked up. Fig. 7 shows a chart taken on another drilling well. The chart was put on at 8:00 a.m. and drilling carried on until 9:40 a.m., when there was a shut-down of 25 minutes to repair the rotary hose. Drilling was resumed and except for a 20-minute shut-down at 12:30 p.m. while changing tours, continued until 3:15 p.m. From 5:30 p.m. until 6:50 p.m. a round trip was made with the drill pipe.

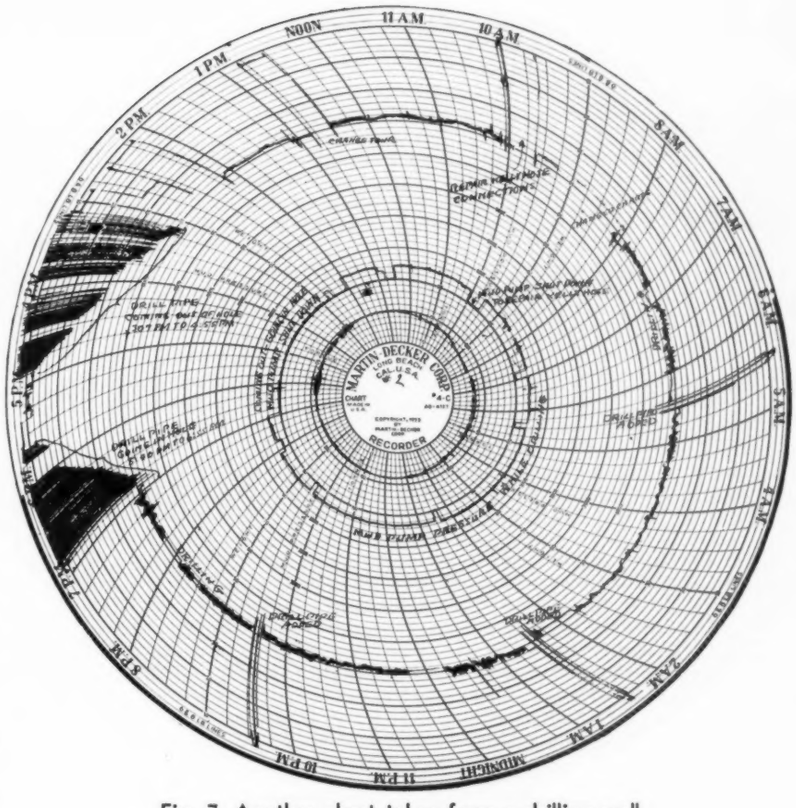
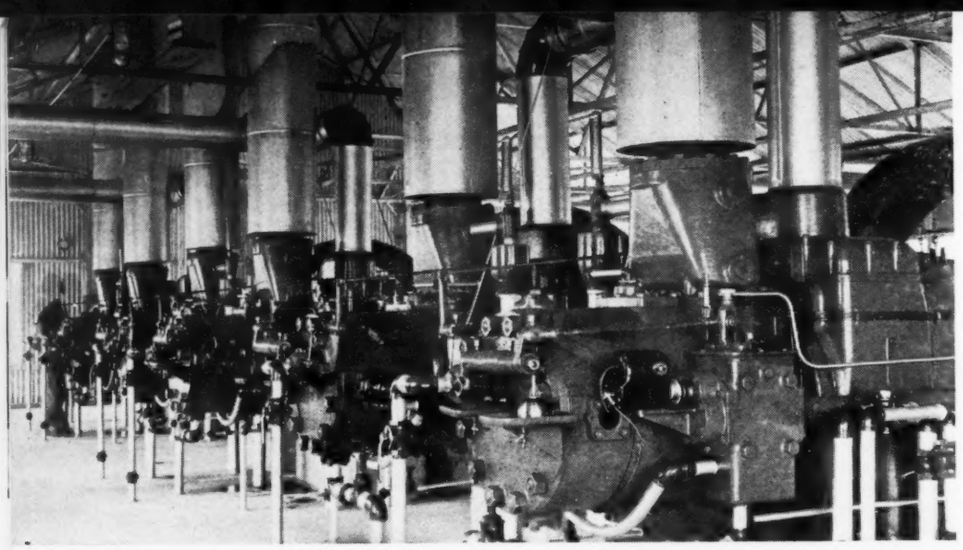


Fig. 7. Another chart taken from a drilling well

With the exception of short shut-downs at 9:30 p.m., 1:30 a.m., and 5:30 a.m. for adding a stand of drill pipe, drilling was carried on steadily from 6:50 p.m. until 8:05 a.m. During this period the torque was quite consistent at 20 to 30 lb. and except for a short period between noon and 3:00 p.m., the torque record shows quite clearly that the bit was dragging, caused, no doubt, by lack of clearance and bit dullness. When the driller noticed that the torque was increasing, it was the signal for him to pull out, which he started to do at 3:10 p.m. It is of interest to note the steadiness of the weight carried on the bit and how uniform was the torque carried on the drill stem during drilling. The record shows clearly the various changes of weights and accompanying changes of pump pressure and torque.

A complete record of drilling operations at the well such as those charts provide is an invaluable means of checking abuses at the well and in reducing if not wholly eliminating drill pipe trouble of the type now prevalent in the Capitol extension of the Oklahoma City field. Were the use of such records universally adopted and the information obtained consistently used, the life of drill pipe would be greatly increased, drilling costs lowered, and drilling speeds vastly improved.



Left—Power end of three Type 12 Cooper-Bessemer gas engines in high-pressure compressor station of E. H. Moore, Inc., in Fitts Pool

Below—By-pass arrangement so pressure from high-pressure cylinder can be transferred automatically to intake of intermediate, and from intermediate to low-pressure if and when pressure becomes too high because of field conditions

By
J. C. ALBRIGHT

●

With an adequate volume of gas under sufficient pressure essential to complete wells by this method, E. H. Moore, Inc., found it necessary to erect a compressor station for the purpose.

●

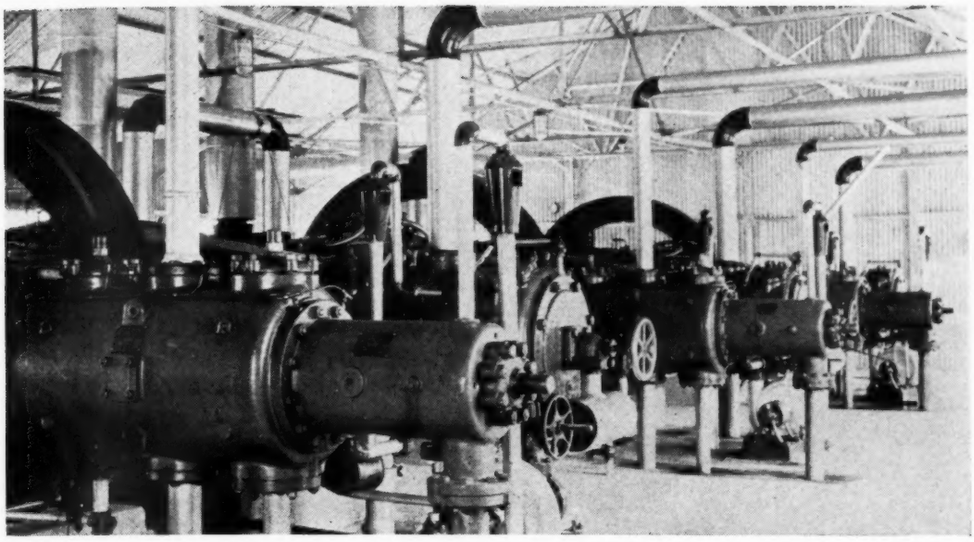
Gas Compressor Station—An Adjunct to Pressure-Drilling in Fitts Pool

PRESSURE drilling has been developed to such a degree of efficiency in completing wells that it is used in the Fitts field of Pontotoc County exclusively by E. H. Moore, Inc., who has the largest interest in that pool. To complete wells by this method, it is essential to have available at all times a supply of gas in the field under sufficient pressure and in adequate volume. When the field was in its prime the gas pressure was such that gas could be obtained from some of the wells and piped to others that were about to be completed in the formation desired. Later, as the number of wells drilled increased, the gas pressure from the available sources declined to such a point that it became necessary to erect a compressor station to serve these drilling wells.

A compressor station for this purpose erected by E. H. Moore, Inc., is new in every respect, from intake scrubbers to outlet meters, and contains three of the latest type Cooper-Bessemer engines. These engines are known as the Type 12, have a rating of 250 hp. at 200 r.p.m., and are equipped with gas injection power cylinder heads. Gas compressed by these three engines is received from a gasoline plant about a mile to the west, owned and operated by the Carter Oil Company, and is delivered to the compressor station at a pressure of approximately 35 pounds. It is essential to boost the gas from this low intake pressure to a maximum of about 850 lb., so that it reaches the well at a pressure sufficient for pressure-drilling operations.

The dry, stripped residue gas from the gasoline plant is first handled through a scrubber where the delivery line from the gasoline plant is attached on one side, and the line leading to the compressor intake header is attached to the opposite side. All the gas passing to the compressor station is measured by Westcott meter; another instrument meters the gas used for fuel in the compressor engines. As the gas entering the compressor station has been cooled and stripped of its available gasoline, the temperature is not sufficiently high that it is necessary to pass it through additional coolers before it enters the intake of the first compressor cylinder.

Three stages of compression are used in this plant. The high and intermediate manifolds are equipped with adequate by-passes so that the gas can be utilized either for pressure drilling alone or for fuel in drilling rig boilers. When the demand for high-pressure gas is greatest, all the gas possible is compressed through the full three stages and sent to the field through the pressure-drilling system of pipe lines. The



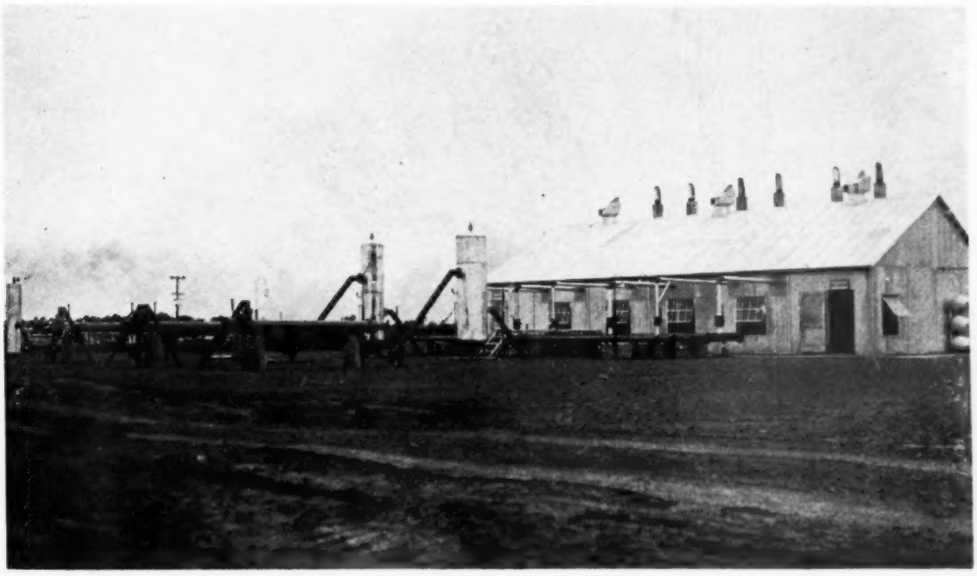
Compressor end of three Type 12 Cooper-Bessemers in high-pressure compressor station of E. H. Moore, Inc., in Fitts Pool. Three-stage compression is employed, with 35-lb. intake, and 800-lb. discharge

surplus, if any, is sent to the field through a separate set of delivery lines and used for boiler fuel.

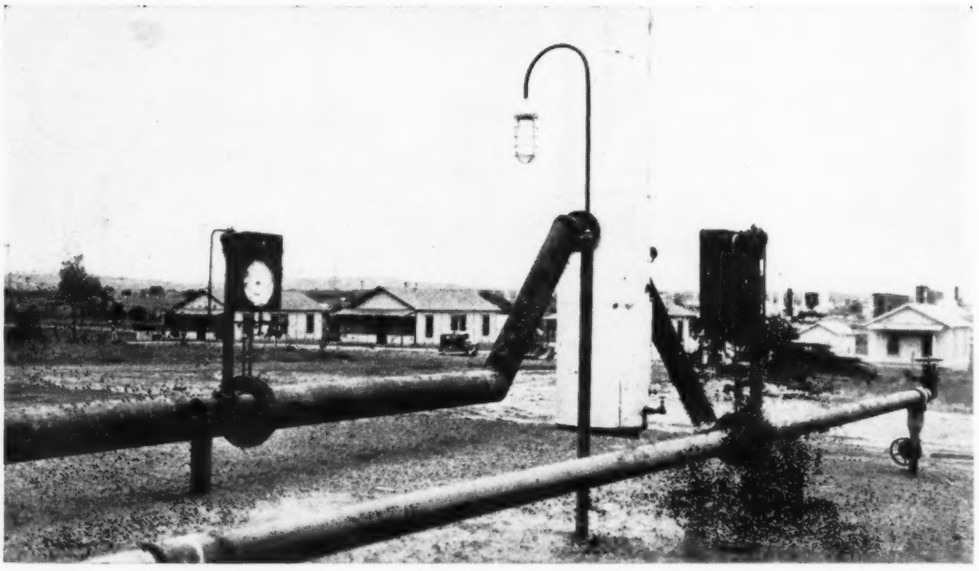
The cooling system of the plant supplies cooling water to the cylinder jackets of the engines and also to the enclosed tubular units through which the gas passes between stages of compression. Water is supplied by a common system maintained throughout the field and enters this station through the hot well, which is controlled by a float valve. Circulation of water through the plant is partly by gravity and partly by pumping. Each engine is equipped with an individual belt-driven centrifugal pump on the engine room floor between the compressor cylinders of each twin unit. These pumps take suction from the outside hot well and lift the water to a Fluor cooling tower placed upon a steel substructure, which elevates it well above a 1600-bbl. wooden supply tank. The ground level where the tank is situated is sufficiently high that circulation is assured even if the water level is low. Lines connect the tank to the outside gas coolers and the water jackets, thus circulating the cooling water by gravity.

All piping in the compressor station is placed above the level of the ground so that operation of the control valves is made easier and also so that corrosion due to unfavorable soil conditions will be retarded. All gas headers are placed upon concrete supports and lie parallel to the engine room. The intake and discharge lines are attached to the headers at an angle so as to reduce eddy currents and line friction. There are six of these headers, the one nearest the compressor room being the low pressure intake header, from which each engine receives its supply of gas under 35-lb. pressure. The discharge from the low-pressure cylinders enters one of the Alco enclosed tubular coolers, where the temperature caused by compression is reduced before the gas reaches the inlet to the intermediate cylinder. The second header receives the gas from the low-pressure coolers and is the intake header for the intermediate cylinders, which in turn discharge the gas to another of the tubular coolers.

Each of the several headers is supplied with adequate control valves so that gas may be switched either to the drilling fuel system or the pressure lines leading to the wells about to be completed by pressure drilling with either the Otis head or a Hydril unit. Each of the Nordstrom Hypresseal lubricated plug valves on the by-pass and flow control lines has a permanent handle so that the operator may switch instantly from one type of gas delivery to another when the occasion arises. Supplementary by-passes are installed on the headers so that if and when the pressure drilling system is shut off at a completed well, the gas automatically passes to



High-pressure compressor station of E. H. Moore, Inc., in Fitts Pool, used to deliver fuel gas through company leases and to supply gas at sufficient pressure so wells can be completed under pressure



Recording meters in compressor station of E. H. Moore, Inc., in Fitts Pool
Left: intake to plant
Right: fuel line to compressors

the drilling fuel system. In the same manner, if an excess of gas enters drilling fuel system for the moment, another automatically-operated pressure release valve returns the surplus gas to the intake of the intermediate cylinder or the low-pressure unit, thus permitting the gas to circulate through the compressors without building up a pressure that might damage the equipment. Likewise, relief valves are installed on the discharge lines from each low-pressure cylinder to pop gas to a vent line should delivery of gas to either of the two gas systems be stopped without the operators of the compressor station having been notified.

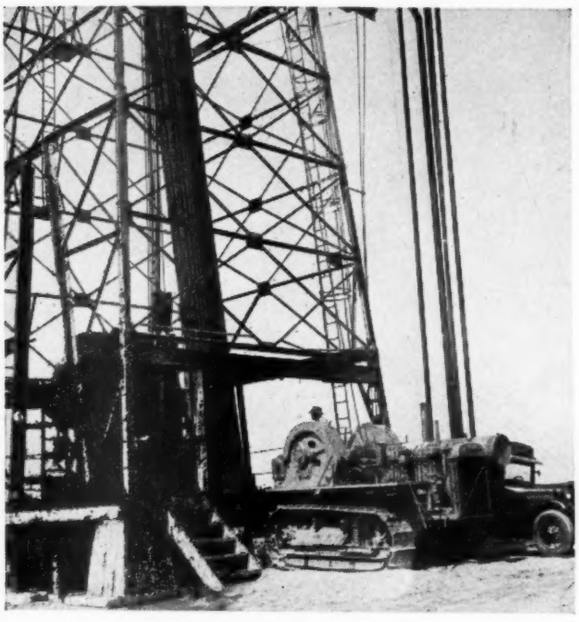
Four Bristol pressure recording gauges are installed inside the engine room so that a record of the pressures throughout the compressor system can be obtained throughout the day. These recorders not only provide a permanent record of the conditions existing in the station, but also provide a means whereby the operators may gauge the switching of the gas from one system to another. A record of the pressure of the gas entering the plant from the gasoline plant not far distant is obtained upon one chart, while the remaining gauges record the low-pressure, intermediate, and high-pressure cylinder discharges. The instruments are installed on a board placed on the wall of the building near the compressor cylinders at a position convenient for the operators on duty.

An adequate system of measuring gas passing through the plant by means of several orifice meters is employed by E. H. Moore, Inc. The intake at the gasoline plant, gas lines from wells, lines leading to the plant fuel system, to the high-pressure drilling wells, and to the drilling boilers, are equipped with Westcott recording instruments. In this manner an accurate record is made available of the gas utilized for the different purposes in the field.

As the soil upon which the plant is built is a sandy loam that causes considerable dust to eddy around the buildings when the wind blows, provisions were made when the plant was built to grade the yard and sod the surface in order to reduce the amount of abrasive material entering the power cylinders of the engines. Air is admitted to both cylinders of each twin Cooper-Bessemer unit through a Vortox oil type self-washing air cleaner on a common line from outside the building. By using an efficient air-washing unit, the life of the equipment will be materially increased and maintenance costs correspondingly decreased.

Alco gas coolers used in high-pressure compressor station of E. H. Moore, Inc., in Fitts Pool

Top—Running the electrodes into a well to measure the electric resistance, which locates the point of entry of water. The truck is equipped with a hoist and the cable is measured into the hole. Instruments for measuring the resistance are in the cab



Below—A portable hoist servicing a deep well in a California field. The hoist here shown will serve as a drawworks and when equipped with rotary attachment can be used for drilling and subsurface repair work

Modern Subsurface Maintenance Methods In Wells

Improved conditions in oil industry have resulted in more consideration being given to efficient production

By WALLACE A. SAWDON
Petroleum Engineer, Los Angeles

DURING the past few years, with curtailment a big factor in all production programs, there has probably been little incentive to increase production. Yet subsurface maintenance frequently is necessary to a widely varying extent under different conditions; and efficiency of production must always be given careful consideration. Wells cannot be abandoned when a little repair work will put them on a profitable basis. With better conditions in the oil industry quite evidently in sight, there should also be a tendency to increase the production of individual wells to the maximum; and the next few months should see a great deal of attention being paid to subsurface repairs.

After completion, it is seldom economical to leave the necessary equipment at the well for either servicing or repairing the hole. Portable hoists and drawworks have established a definite place for themselves in meeting this condition. In California, such hoists are powered with electric motors or with Diesel engines as well as with gas engines. They are being mounted on trucks, tractors, or trailers to meet the demands of the operators or to fit in with the field conditions of the localities that they have to serve. While the hoist is primarily used for pulling rods and tubing, many of the larger designs are equipped with rotary attachments that aid greatly in subsurface repair work.

There will frequently be specific causes for impeded production that will require the application of specially planned corrective measures. Water entry usually presents a problem that necessitates specific study both as to location and exclusion. Paraffin troubles are not so serious in most California fields as they are in other places. But with some formations there will always be the accumulation of solids and other foreign matter to contend with; and the proper methods for the removal of such material should be determined to provide economic maintenance.

Clean-out Work

The accumulation of sand, solids or other material that does not come out of the well with the oil generally will result in: (a) sanding-up of the hole or the formation of a bridge; (b) clogging of perforations where perforated liners or screens are used; or (c) the forming of an impervious sheath over the sand face. The use of a fluid, generally crude oil, has been a means of meeting these conditions for many years but new devices have been designed that will, in many cases, prove more economical and efficient. Many engineering principles have been applied in meeting the problem and a few of the devices being used in California will indicate the advancement in cleaning-out methods.

The bailer will, of course, often be able to remove sand and other débris that collects in a hole or forms a bridge. The circulation of fluid or hydraulicking is also used to some extent to mix the solids with the fluid and bring them out of the well with it. In many cases, however, the material at the

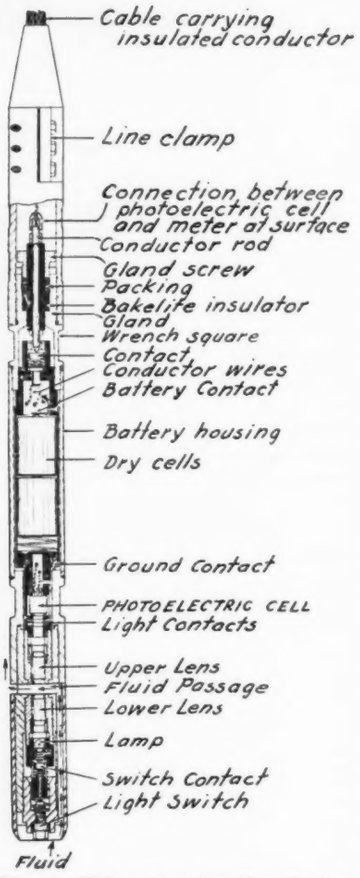


Fig. 1. This water-locating instrument utilizes the photoelectric cell to determine the point of water entry

bottom or in the bridge will resist efforts of removal by these means.

When equipment is not available at the well to drill out the bridge or to clean-out to bottom, the hydraulic sand pump has been used to advantage. This device is run on a wire line and utilizes the hydraulic pressure provided by the fluid head in the well to force material into an upper pump chamber, which is maintained with air at atmospheric pressure until the device reaches bottom and the pump put into operation. The differential between hydrostatic and atmospheric pressure is the force applied in forcing the solids into a lower chamber of the pump, and the greater the fluid head, the greater this force will be. Of additional advantage is the suddenness with which the pressure is applied to give a sort of explosive action. Pieces of metal and rock that could not be forced by hand through the flapper valve at the bottom of the sand pump have been found in the lower chamber. The general principle employed by the hydraulic sand pump has been given in a previous issue of *The Petroleum Engineer*.[1]

Clogged perforations present a different problem. Fluid to clean out holes, slots, or screens in the pipe, has been used for many years and in different ways to meet conditions. In some cases flooding, or filling the oil string with the fluid, has been all that was necessary. In others, jets of fluid have been directed against the openings under pressure. Hydraulicking has also been used with success. Many new devices for utilizing the fluid most effectively, however, have been perfected and these have aided greatly in well washing.

Another method is to use the fluid in the hole without pumping other fluid into the well. One perforation cleaner of this type is run on the bottom of the tubing until it reaches the depth where the perforations are to be cleaned. It is there anchored and, by moving the tubing up and down, the fluid in the hole is forced in and out of the perforations to remove any solid matter that may be clogging them.

A recent development in perforation cleaners is the application of acid under pressure. There is a possibility that the use of acid when properly applied will be of value in acting on any accumulation of solids behind the pipe as well as cleaning the perforations; but further results will have to be studied before a comprehensive report on this method can be presented. Fields outside of California may offer better opportunities for developing this method.

Cleaning off a sheath of accumulated material from the face of the sand offers greater difficulty than sanding-up, bridge formations, or clogged perforations. It is hard enough to clean such a sheath of foreign matter from a sand without the obstruction offered by a perforated liner or screen; but when the cleaning action has to be performed through holes or screen, the difficulty is greatly increased. The character of the solids and their cementation will, of course, have considerable influence on the method to be used in removing them. Their disintegration in the fluid used is necessary, and even if they can be loosened from the face of the sand, it is sometimes questionable if the entire surface can be cleaned.

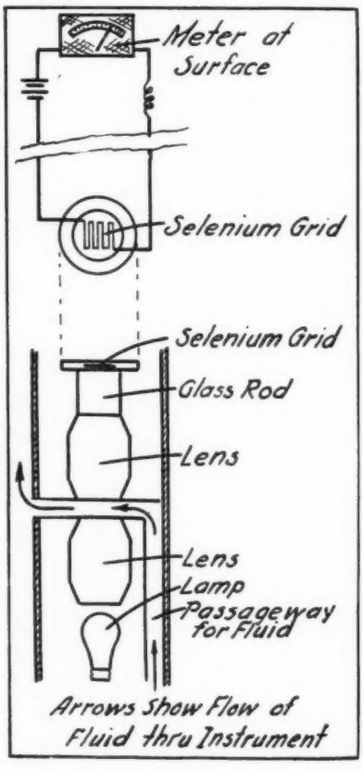
When it is possible to do so, an effective method is to pull the liner and scrape the hole through the entire producing thickness. In doing this, the hole may or may not be enlarged but in most cases it will be found advantageous to use a wall scraper and cut away some of the original producing face to give a virgin wall that will offer the least resistance to the flow of oil into the hole. In one case in the Long Beach field, production was increased from 30 to more than 200 bbl. per day.

It must, of course, be remembered that the oil sand may be so depleted that all the cleaning in the world will not increase production. In some cases, however, some cleaning-out method may help to lower lifting costs and may be well worth while for this reason alone. A careful study of the well history will often be the only means of determining to what extent cleaning out should be done; and certainly such a study will aid in a determination of the method to be used.

Water Entry

There are many instances where water is considered as coming from the oil sand. Where this is true, there is nothing to do but to go on producing the oil and water together. The point of water entry is sometimes hard to discover; but the deleterious effects of water warrant every effort to discover its source so that it can be shut off. There are many cases where it has been thought that the water being produced with the oil was present with the oil in the sand, but after investigation would be found to have a different source. The annoyance and expense of producing oil with water is not the only thing to consider. Water may often have a serious effect on the sand; it may hasten

Fig. 2. Method for measuring translucency of fluid in a well to determine water entry is here shown diagrammatically.



[1] "Utilizing High Hydrostatic Pressure in a Well for Cleaning Out." *The Petroleum Engineer*, March, 1934.

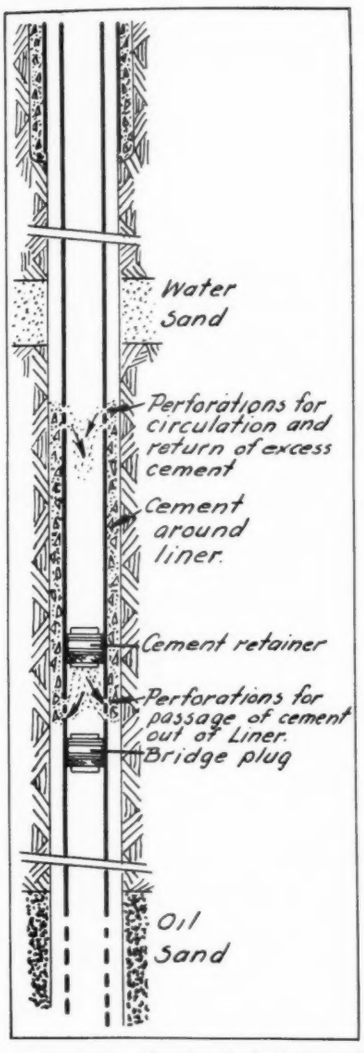


Fig. 3. Method of shutting off water behind casing by cementing through perforations with special equipment.

abandonment and reduce the ultimate yield of a well to a considerable extent. Its presence should certainly warrant immediate corrective measures.

A study of the well's history may disclose the source of the water and provide a means of shutting it off with little difficulty. Unfortunately, the point of entry is not always so easily disclosed. Besides the usual methods for testing to find the source, several devices have been used to a considerable extent in the California fields to determine the accurate point of water entry. Two of the methods used are electrical devices[2] and have been employed with considerable success.

The most recent device developed for the location of water in a well utilizes the principle of the photoelectric cell and measures electrically the difference in transparency of fluid to determine the exact point of entry. The instrument, as shown in Fig. 1, is lowered into the well on armored cable that contains a conductor wire to transmit variations in current to a meter (similar to an ordinary micro-ammeter) at the surface. As the instrument moves down the hole, a stream of the fluid in the well passes continuously through it and the translucency of this stream provides the data from which the point of water entry is determined.

In making a survey, the hole is conditioned with muddy water until a column of uniform opaqueness is obtained throughout the distance in which the water is believed to enter. The intruding water will dilute this prepared fluid column and by making the greatest dilution at the point of entry thus increase the transparency of the fluid at that point. The maximum amount of light will therefore penetrate through the stream when the instrument reaches the depth where the water enters the well.

The operation is indicated in the accompanying diagrammatic drawing, Fig. 2. As the fluid is forced through the instrument by its downward travel, the stream passes between two lenses. Light rays from the lamp are directed through this stream and are focused on a selenium grid at the bottom of the photoelectric cell. Variations in current produced by the different intensities of light, which are caused by the varying opaqueness of the fluid, are picked up by the photoelectric cell and are conducted by wire through the cable to the meter at the surface, where they are read.

The selenium grid receives a current of three volts, which, together with that going to the lamp, is supplied by batteries. The instrument run into the well is $1\frac{5}{16}$ in. O.D. It is lowered on a cable by means of a hoist mounted on a truck and its exact depth during operations is indicated by a counter. The depth and light unit readings are recorded synchronously at intervals that best meet the conditions obtaining on a specific job. The instrument is tested to withstand a pressure of 4500 lb. per sq. in. to provide against leakage under high hydrostatic heads.

The fluid below the point of water entry is not diluted so the readings return to normal for the conditioned column after passing the source. Should water enter at more than one point, a circulation of the sediment occurs at each source to make detection easy. The presence of oil does not interfere with the operation, because oil retards the passage of light. In order to prevent oil or other material from forming an obstructing film, however, a transparent colloidal coating is used on the lens.

Shutting Off Water

After the point of water entry has been found there remains the problem of shutting it off effectively. Frequently this is not difficult; but it always requires individual study. Cementing is often the only means available for effecting the repair work and such cementing usually presents problems that are more difficult of solution than the original cementing of a string of casing. While the mechanical process of handling the cement and putting it down the well is practically the same in all cases, special equipment is often necessary in placing the cement where it will be effective.

The technical phases of this kind of work are usually of particular importance. A knowledge of conditions existing down the hole is necessary;

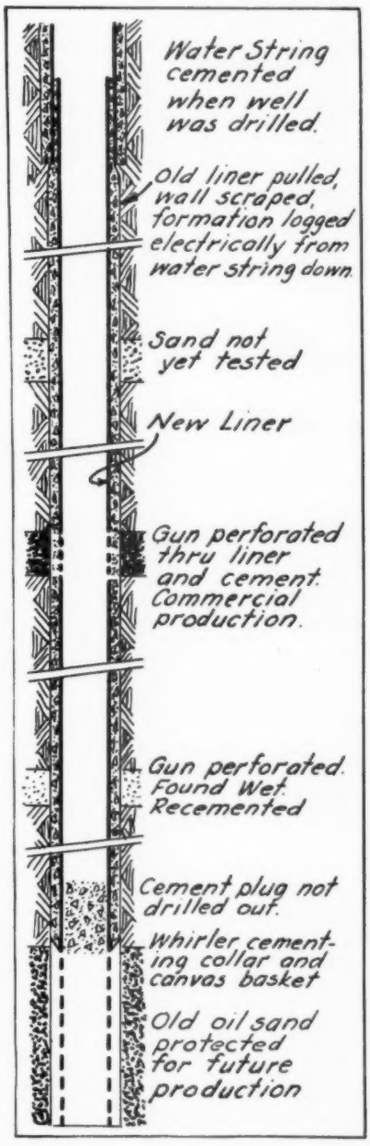

Water String cemented when well was drilled.
Old liner pulled, wall scraped, formation logged electrically from water string down.
Sand not yet tested
New Liner
Gun perforated thru liner and cement. Commercial production.
Gun perforated. Found Wet. Recemented
Cement plug not drilled out.
Whirler cementing collar and canvas basket
Old oil sand protected for future production

Fig. 4. Method of testing upper zones for production and at the same time clean-out lower producing zones and protect them for further production.

[2] "Field Development Operations Go Scientific," by A. C. Rubel, *The Petroleum Engineer*, December, 1934.

and on this knowledge must be based the entire operation. A recementing job is not always concerned with the well history; repair work, on the other hand, usually is. Before any plans are made, all drilling and production data should be thoroughly studied. The production record may show the cause of trouble and the drilling record should help disclose the condition of the hole. In addition to knowing the point of entry of water, geological data will often help explain the cause of the trouble and help make the repair job most effective.

In cementing off water, the pipe can often be perforated to advantage so that cement can be forced through special equipment, such as a cement retainer, and be placed through the perforations so made into the annular space behind the pipe at the point of water entry.

This procedure is illustrated in Fig. 3. In this case, the water started to enter at the top of the perforations but it was known from core records taken during drilling that the water actually originated in a sand some distance above. The liner (a combination string) was perforated with six holes below the water sand and five holes above. A casing bridge plug was placed just below the lower perforations and a cement retainer set above them. Circulation was obtained through the retainer, out through the lower perforations, up behind the liner with the excess allowed to flow back into the liner above the retainer. When the cement had set, the cement retainer casing bridge plug and the cement left below and above the retainer were drilled out.

Perforators

While not strictly maintenance work, increased production from a well is often obtained from sands passed up while drilling. Both the mechanically-operated perforators and the "gun perforator" have been used successfully in the California fields to make entry into a hole through casing that is protecting upper productive zones. Considerable attention has been focused on the gun perforator and its action has been described in detail.[3] It is especially advantageous where two or three strings of pipe, even with the annular space between them filled with cement, have to be penetrated.

Plugging-back operations should be given careful consideration when production from a lower sand is to be abandoned and oil is to be taken from a higher zone. A complete shutting off of water from below may not always be easily accomplished if pipe left below the new production is not cemented both outside and inside.

The use of perforators may also be found of value in reperforating old liners that cannot be readily pulled or put into good condition; also, for making additional perforations, especially in the upper portion of a zone after water has appeared in the lower members and has had to be shut off.

Recompletion work involving the redrilling of a portion of old wells to revive production is being done to a considerable extent in some California fields. The use of the whipstock for this purpose has increased during the past year or two. This is frequently done by milling out through casing with the old bottom plugged off effectively in a manner governed by conditions.

A method now being used when it is desired to test upper zones previously passed up but at the same time clean-out a lower producing zone and protect it for further future production when desired was developed in Long Beach. The old liner is pulled and the entire portion of open hole below the cementer water string is scraped. The formations up to the water string are then logged electrically and the possible productive zones located. As shown in Fig. 4, a liner, perforated only opposite the old productive zone, is run and completely cemented through a cementing collar from the top of the perforations up to the water string. A cement plug is left in the pipe above the perforations.

Gun perforations are then made through the liner and the cement at the lowest prospective zone above the old producing sand. If this does not prove commercially productive, the perforations are cemented off by a squeeze job and the next favorable formation above them is tested in a similar manner.

[3]Complete details of the operation are given in an article, "Electrically Operated Gun Proves Effective for Perforating Cemented Casing in Hole," *The Petroleum Engineer*, February, 1933. The effective use of the device is shown in "Field Development Operations Go Scientific," *The Petroleum Engineer*, December, 1934.

New Diesel Electric Rotary Drilling Unit Operating in Kansas

A NEW Diesel electric rotary drilling rig has been recently placed in service near Hays, Kansas. With a capacity suited for drilling to the moderate depths prevalent in the Kansas fields the rig has drilled several wells and has proven its economy in operation.

The first well drilled with this unit has a total depth of 3480 ft. and was drilled in 11 days from below the surface pipe, including 80 ft. of coring. Drilling to this depth required 117 bbl. of fuel oil (42 gal./bbl.), costing approximately 5 cents per gal. delivered to the location, and 194 gal. of lubricating oil.

Although these figures indicate economical operation, it is probable that on future wells the operating costs will be reduced because minor adjustments ordinarily required when new equipment is operated for the first time usually are not necessary after the first well has been drilled. The regular drilling crew, including a combination roughneck-electrician, installed the unit on its second location. As an indication of the simplicity of the rig, this electrician had to change only two wires when the rig started to drill the second well.

This drilling rig is powered with two Superior 9-in. by 12-in., 6-cylinder, 260-hp., 600-r.p.m. full Diesel engines driving two 125-kw. d-c. 1200-r.p.m., 250-200-volt motors with 15-kw., 115-volts, direct-connected exciters. The two drilling motors, rated 150-hp. 900-r.p.m., 200-volt d-c., and are shuntfield, separately excited, two-bearing bracket type with forced ventilating covers and blowers mounted on the motors. A 150-hp. 900-r.p.m., 200-volt d-c., bracket type motor drives the slush pump. All the electrical equipment including switchboard and controls were supplied by the Westinghouse Electric and Manufacturing Company.

View showing one of the Diesel engines and the electric generating units. This picture was taken while rigging-up.

Inspection of Rubber Pipe Line Coating

By

ELMER F. SCHMIDT

General Superintendent, Lone Star Gas Company

Above—Soft rubber sleeves were used to protect joints at welds. It was necessary to replace these with Koroseal coated tape with Koroseal solution used to bind the tape

Left—Showing a portion of the pipe uncovered. The rubber coated center rings of couplings were in excellent condition

ABOUT a year ago the Lone Star Gas Company installed a 100-ft. section of rubber-coated 10-in. pipe in one of their lines about ten miles southwest of Waxahachie, Texas. The soil at this location was known to be highly corrosive. This coating was the result of five years of research effort by the development department of The B. F. Goodrich Company. The rubber was vulcanized to the steel pipe at the Goodrich factory in Akron, Ohio, leaving about ten inches of the pipe bare on each end. Five 20-ft. joints of the coated pipe were welded into a continuous section at the location where it was to replace a 100-ft. section removed from the line.

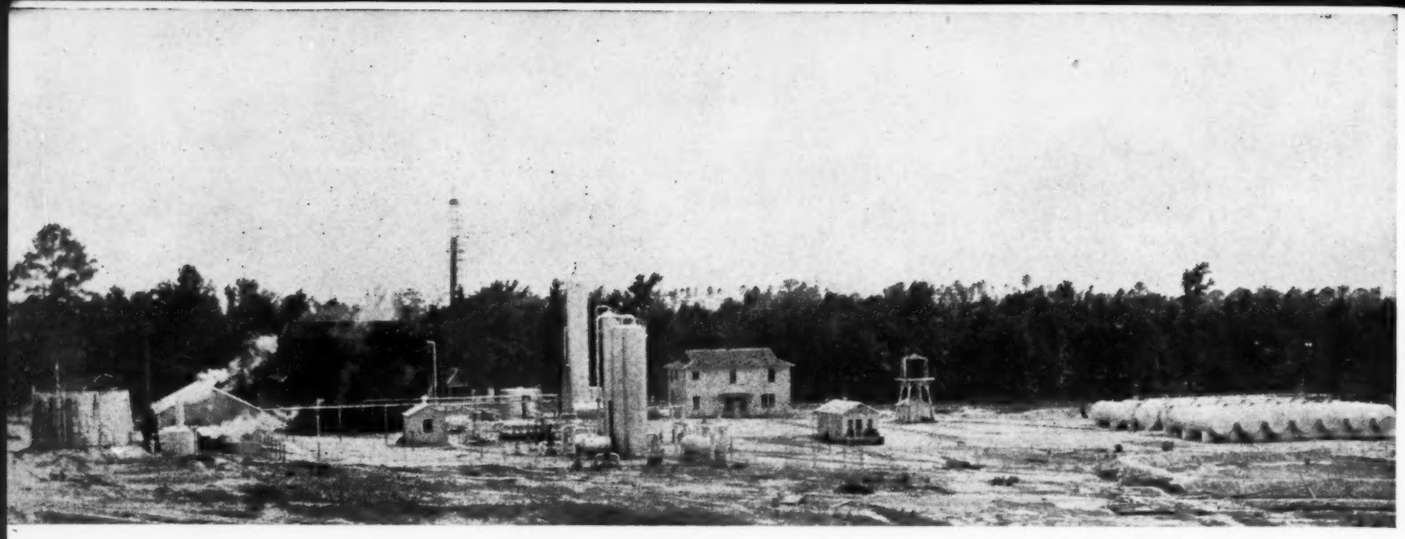
The joints at the welds were protected with unvulcanized rubber sleeves, which were cemented to the pipe and extended several inches over the rubber-coated pipe. This sleeve was then wired firmly with several bands of wire. It was thought that this soft rubber sleeve would in time freeze to the pipe and vulcanized coating, and thus protect the ends.

Recently this section of pipe was uncovered for inspection. Dr. H. E. Fritz, manager of chemical tests and developments for The B. F. Goodrich Company at Akron, Ohio, who supervised the original installation, and other Goodrich engineers, were present along with officials of the Lone Star Gas Company.

The factory vulcanized coating was in perfect condition, showing no signs of breaking down nor any defects whatsoever. The soft rubber sleeves at the joint, however, had not gripped the pipe sufficiently to exclude water from seeping along the seams and there was evidence of rusting and some pitting of the pipe having already set in.

Two of these sleeves were removed and a new type of protection, known as Koroseal coated herringbone tape and a liquid called Koroseal solution used for binding the tape, was employed in protecting these joints. The uncoated pipe at the welds was carefully cleaned and coated with Koroseal solution, which was heated to a temperature of approximately 200 deg. fahrenheit. The tape was thoroughly impregnated with a solution of Koroseal and the solvent evaporated, leaving the solid, flexible, rubber-like Koroseal completely dispersed throughout the fabric. When the tape was put on, it was again wet with a solution of Koroseal, which solution makes the fabric tacky so that when spiralled on it knits together. After the fabric had been spiralled in place, three coats of Keroseal solution were applied in order to assist in the sealing action.

From the relatively short test, the rubber-coated pipe gave excellent results and the rubber-coated center rings used in the couplings at each end of the test section also showed no signs of breaking down in this corrosive soil. This test will be inspected annually and if the new joint material performs as well as the rubber coating, it would appear that 100 percent protection can be obtained by this method.



General view of Pelican Oil and Gasoline Company's new gasoline plant at Rodessa

Absorption-Pressure Type Gasoline Plant for Rodessa

By

FRANK H. LOVE

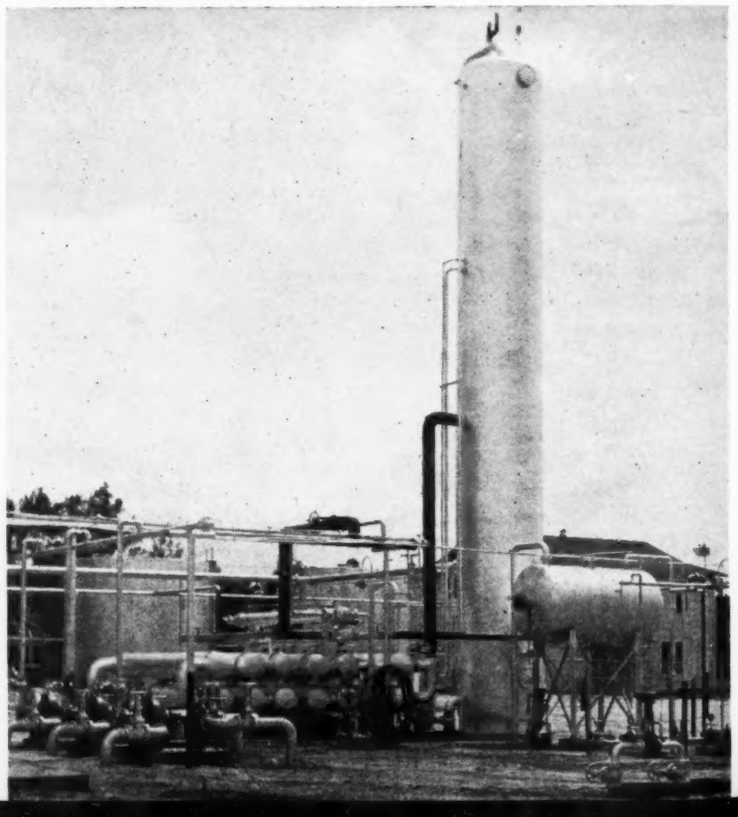
Pelican Oil and Gasoline Company, Inc., completes unit having rated capacity of 50,000,000 cu. ft. of gas daily with 50% overload—50,000 gal. of gasoline, principally 26-lb. grade, manufactured every 24 hours.

A NATURAL gasoline plant of 50,000,000 cu. ft. capacity, designed to manufacture 50,000 gal. per day, has been completed and placed in operation in the Rodessa field of Louisiana by the Pelican Oil and Gasoline Company, Inc., the largest of recent construction in the area. The unit is of the absorption-pressure type and is capable of handling a 50 percent overload.

Equipment throughout is the most modern and the plant is laid out and constructed in a manner to afford the greatest degree of efficiency. The high-pressure bubble tower absorber, 54 in. in diameter by 50 ft. in height, has a rated capacity of 20,000,000 cu. ft. of gas per day, and is equipped with two 16-in. external man-ways, as well as internal man-way through the trays, making the latter and the caps easily accessible for cleaning, inspection, or repair. The two low-pressure bubble tower absorbers have a rated capacity of 30,000,000 cu. ft. of gas daily. They are 90 in. in diameter and 40 ft. high and have both internal and external man-ways similar to the high-pressure absorber.

The still and condenser units are designed to handle 50,000 gal. of gasoline during a 24-hour period. The former is of the bubble tower type, 84 in. in diameter by 56 ft. in height, also having internal and external man-ways. Mineral seal oil, surge, and storage tanks consist of two 500-bbl. water-tight standard oil country vessels of welded construction. Gasoline storage is provided by 14 horizontal pressure storage tanks, each ten ft. in diameter and 40 ft. in length, having a total capacity of 336,000 gallons.

Water and oil pumps are turbine-driven, some being of the centrifugal, others of the reciprocating, type. Pumping equipment consists of two centrifugal water pumps, two reciprocating steam pumps, three oil circulating pumps, one



Distillation unit, designed to handle 50,000 gal. of gasoline during a 24-hour period

10 by 8 by 12 loading pump, and two units for pumping gasoline reflux to the dephlegmator.

The tubes of the vertical oil coolers and condensers are of admiralty metal. The cooling tower is of the enclosed type and has a capacity of 1800 gal. per minute. The steam plant consists of five 115-hp. oil country boilers.

Another feature of the plant is its complete automatic control. Oil and gas meters are of metric metal construction. Each absorber is equipped with direct reading meters for both oil and gas, and a direct reading recording meter has been placed on each intake gas line.

Electricity for lighting purposes is supplied by a 20-kw. 110-volt generator, steam-turbine-driven. Water supply is obtained from two deep wells. That providing water for the plant is flowed by gas-lift, boosting to a 1600-bbl. redwood storage tank, from whence it is distributed to the various units. The other well, equipped with an air compressor driven by a steam turbine unit, supplies water to the eight employee residences and to the office building. The latter is a two-story structure and in it are the offices for the production division of the Pelican Oil and Gasoline Company, as well as for the plant itself. The second floor of this building has excellently appointed "bachelor quarters" for the unmarried members of the staff.

The laboratory is conveniently situated in respect to the processing units, storage, and office, and is thoroughly equipped to handle both lease production and plant work.

One mile of 4-in. line connects the plant with a ten-car loading rack north of Rodessa.

An incidental feature of the plant, but at the same time an essential one from the standpoint of efficiency, is its very complete system of telephone communication. The system is so devised that contact is possible at all times between the plant and the loading rack; between the laboratory and the rack; the laboratory, rack, and office; and the laboratory, office, rack, plant, and the superintendent's house, without interference with the direct line of regular communication to the Rodessa exchange.

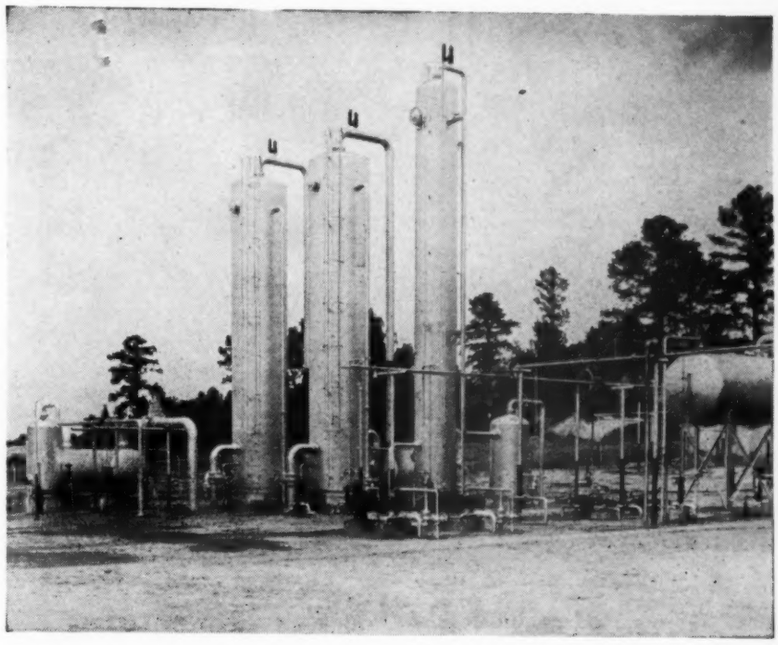
The foregoing gives a general description of the plant's equipment. With regard to flow, usual practice is rather closely followed. The high-pressure gas is gathered from separators in the field, operating at a pressure of approximately 350 lb., and is received at the plant through a high-pressure vertical scrubber 54 in. in diameter by eight ft. high prior to entering the absorber at 325 lb. pressure (the operating pressure of the plant). This gas, after passing through the bubble tower absorber countercurrent to the mineral seal oil, is discharged from the absorber and again passed through a scrubber before being delivered to the fuel system supplying both plant and lease requirements.

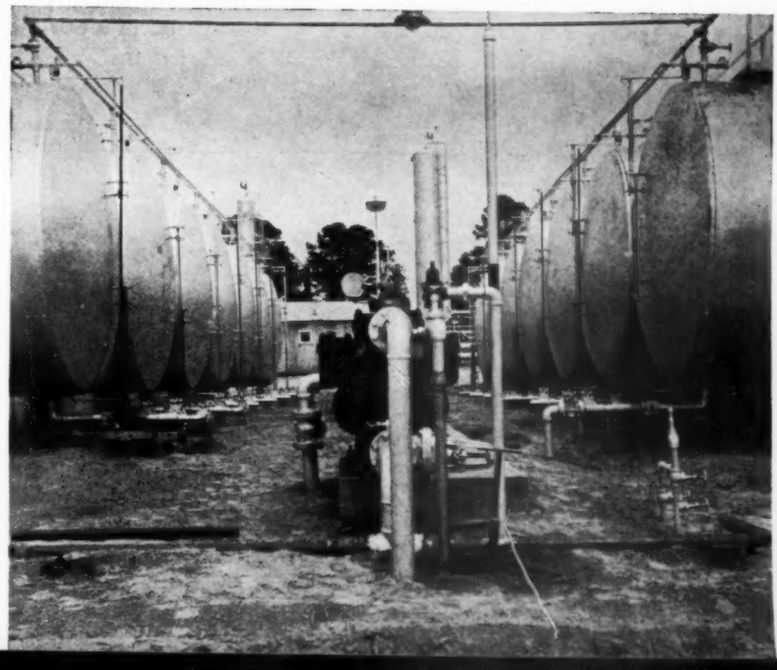
The low-pressure gas is gathered from separators in the field under an operating pressure of approximately 60 lb. and is passed through a 6-ft. by 15-ft. scrubber before entering the low-pressure absorbers, where it passes countercurrent to the mineral seal oil at an operating pressure of 45 pounds. This gas then leaves the absorbers, goes through two 6-ft. by 10-ft. horizontal scrubber tanks and into a 16-in. residue discharge line that leads to a pit where the residue gas from the plant is burned.

The mineral seal oil is first discharged from the surge, or lean oil, tank to the absorbers. The rich oil from the bottom of the high-pressure absorber is delivered into the bottom of the low-pressure absorbers, the gas in solution being partially eliminiated there. The rich oil is then pumped through the heat exchangers, the pre-heaters, and into the still. From the still the lean oil is delivered through heat exchangers, and coolers, back to the surge tank.

Gasoline vapors eliminated from the rich oil in the still are delivered to vertical coolers situated in the base of the cooling tower and thence to an elevated horizontal receiving tank six ft. in diameter by ten ft. in length, from which the supply of reflux is pumped into the dephlegmator section of the still and the additional gasoline thus obtained is sent direct to storage.

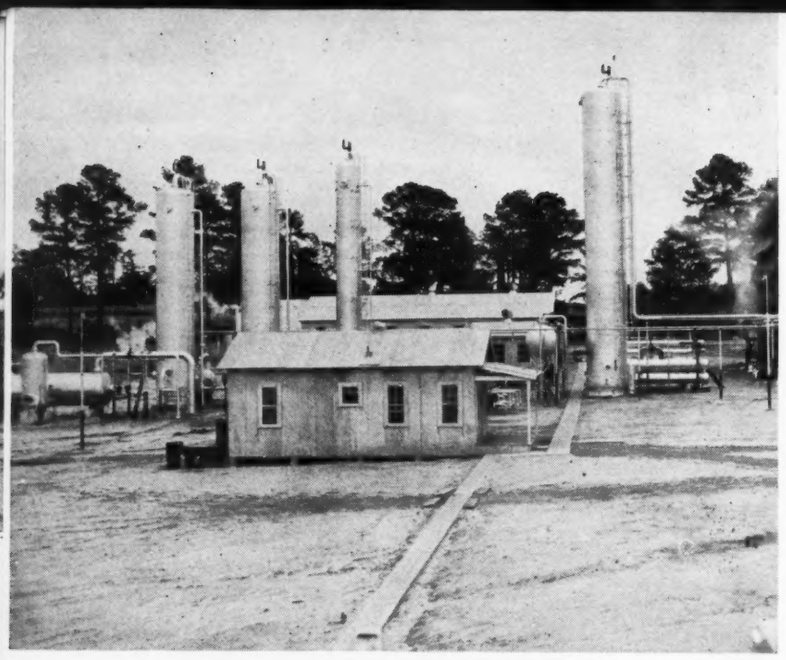
At the present time the plant is producing approxi-

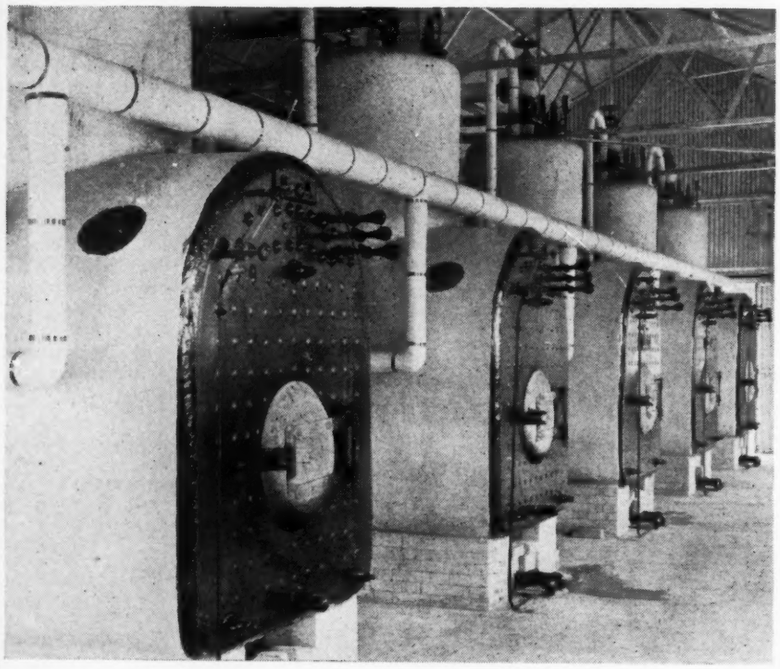




Top—Incoming scrubbers (left), and low- and high-pressure absorbers

Bottom—Gasoline storage tanks and loading pump





Top—View showing laboratory building, incoming scrubbers, absorbers, and distillation unit

Bottom—Five 115-hp. boilers provide steam for the plant

mately 50,000 gal. of gasoline, 43,000 gal. of which is 26-lb. grade, with 7000 gal. of heavier grade taken off as a side stream. The entire production is under contract to the Warren Petroleum Company of Tulsa, Oklahoma.

In addition to the equipment herein enumerated a tail gas absorber and a stabilizing unit have been ordered and will be installed in the very near future.

The gas supply is obtained from 13 wells, all owned by the Pelican Oil and Gasoline Company, Inc. It is brought to the plant under well pressure. The low-pressure gathering lines and the residue lines are 16 in. in diameter and the high-pressure lines 6 in. in diameter.

The gas is sweet, non-corrosive, and requires no treating. A typical sample being processed at the plant has been analyzed as follows:

Compound	*Volume Percent*	*Gal./M Cu. Ft.*
Methane and air	93.62	
Ethane	1.13	
Propane	1.70	
Iso-butane	.57	
N-butane	.95	.30
Iso-pentane	.42	.15
N-pentane	.45	.16
Pentanes and heavier	—	—
Hexanes and heavier	1.16	.50
	100.00	1.11

The Frick-Reid Supply Corporation of Tulsa, Oklahoma, constructed the plant for the Pelican Oil and Gasoline Company, Inc., and W. J. Hunter. Mattison and Wallack Company, Oklahoma City, Oklahoma, were responsible for the erection and the Burrell-Mase Engineering Company, Tulsa, Oklahoma, for the design, which is along lines specified by the Pelican company management.

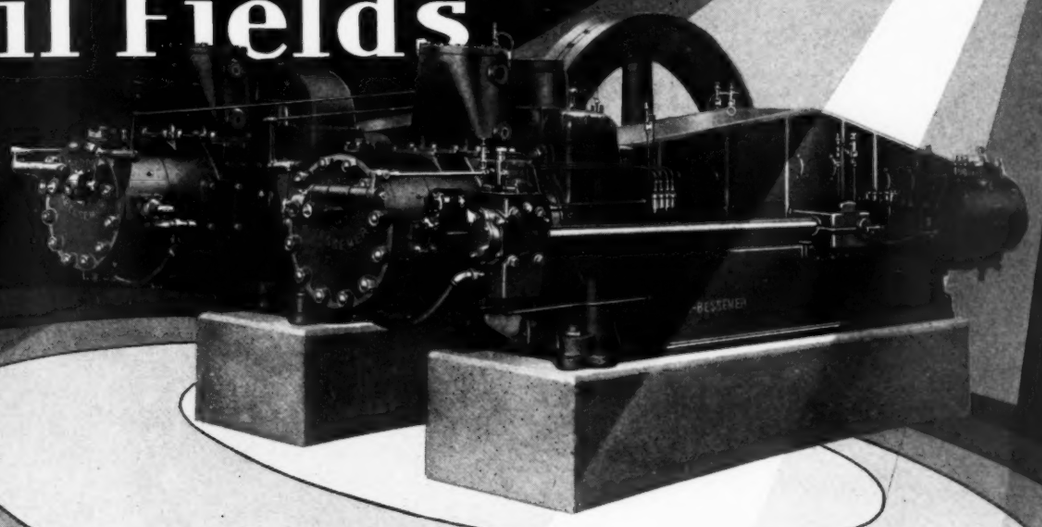
In charge of the operation of the plant are Wm. H. "Jack" Vaughan, general superintendent of the gasoline plant as well as drilling and production operations for the Pelican; L. D. Phillips, plant superintendent; and R. D. Morgan, assistant plant superintendent and laboratory engineer.

Oil Exploratory Work in Australia

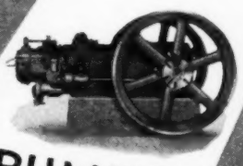
Since the Commonwealth Government has contributed 10,000 pounds to an equal amount made available by the State Government, the Mines Department of Victoria, Australia, has commenced work with two oil drilling outfits. The area chosen was Eastern Gippsland. It is intended to drill to a depth of 1000 ft., although some of the wells put down in the Gippsland oil field have reached 1600 feet. The Federal expert of Oil Survey, the Victorian director of Geological Survey, and the Victorian Minister of Mines, will form an unofficial committee to regulate the allocation of the funds.

Certain of the monies will be used in cementing the abandoned wells that have been sunk through the oil sands into underlying water. Experts fear that if the water is allowed to percolate further through the oil bearing strata, irreparable damage will be done to the whole field.

"TOPS" in the Oil Fields



DIESEL DRILLING



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The new Type-12 twin gives greatest capacity per engine dollar.

Cooper-Bessemer Diesels with patented atmospheric relief injection are outstanding for rotary drilling.

The GAO—40 H. P. single cylinder horizontal gas engine is still the "champ" of low costs over long periods.

Cooper-Bessemer 800—1500 H. P. compressor units are dependable above all.

Topnotch performance puts Cooper-Bessemer Diesels at the head of the list for oil-line pumping.

While these engines are uppermost in your mind, better write for interesting details.

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The Continuous Method of Take-Up On Pipe Lines

By

BARRY FEDERMAN

Fig. 1

BELIEVING there will be an increase in the number of pipe lines taken up for reconditioning in the next few years, the Oklahoma Contracting Corporation of Dallas, Texas, is developing various methods of removing pipe from the ground.

One such system that has proved successful is the continuous method of takeup, whereby the ditching, takeup, and backfill is combined into one simple operation. This method was experimented with on a 4-in. line having an 18-in. covering of soil. A ⅝-in. cable, with ¾-in. collars strung upon it to act as rollers, was placed around the pipe. When pulled down the right-of-way by a tractor it served to loosen the soil around the pipe (Fig. 1). The block of wood shown in the illustration was for the purpose of keeping the cable from binding on the sides of the pipe.

The sled (Fig. 2), constructed from three short sections of pipe, follows the cable cutter and takes up the pipe. A chain is attached to the sled and thrown over the pipe being taken up, serving to knock the soil off the pipe and back into the ditch.

Fig. 3 shows the sled in operation.

Fig. 4 shows the pipe above ground ready to be cut into sections.

The cutting cable and the sled are pulled simultaneously by one tractor. Thus one gang is able to take up many miles of pipe in a day's time.

Fig. 2

Fig. 3

Fig. 4

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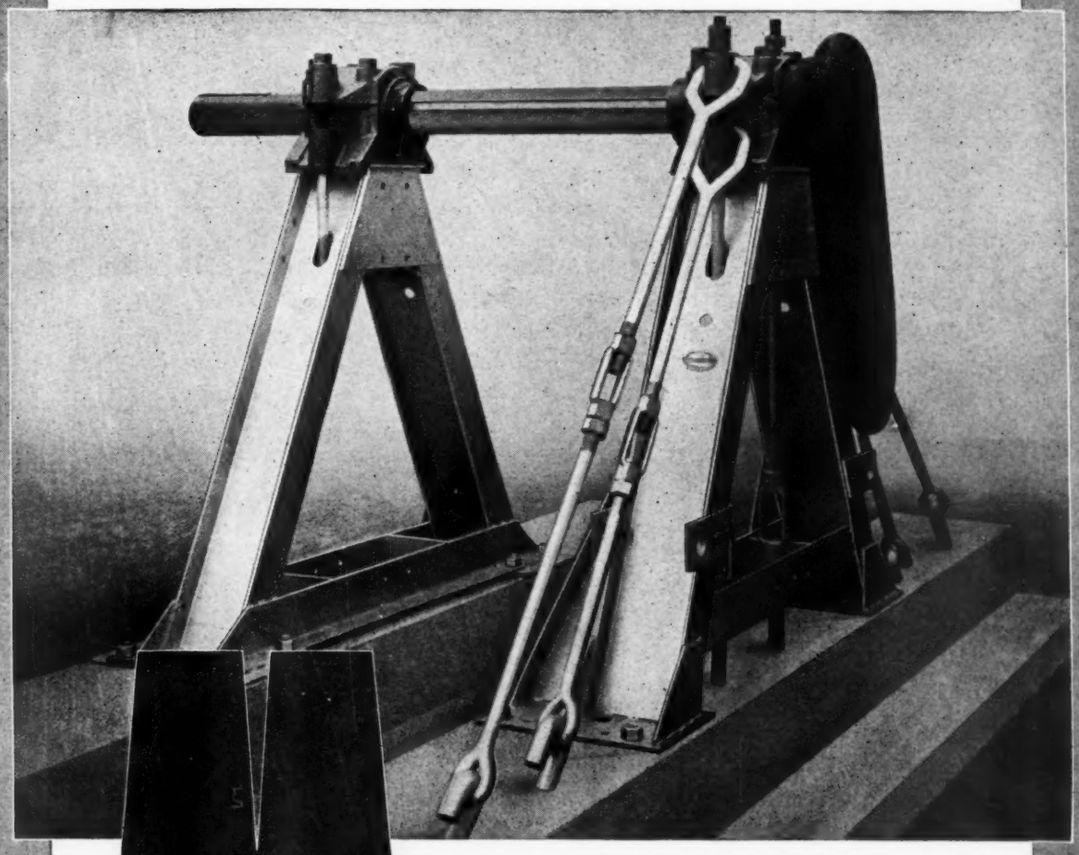

Moore Jack Posts and Bearings stand up under the hardest drilling and pumping conditions. Illustrated is the Type 95-A jack post with Type D chain oiled jack post boxes and double set of diagonal turnbuckle braces. Full details in Catalog Section H.

DERRICKS

PUMPING EQUIPMENT

Moore

The Diesel Engine

Its Classification, Principles of Operation, and Various Applications

By ORVILLE ADAMS, Diesel Engineer

GREAT importance attaches today to the Diesel engine, its operating principles and various applications. No other phase of engineering warrants more immediate and thorough study and attention on the part of operating engineers and those responsible for power production and economy of operation.

It is the purpose here to present a basic viewpoint and outline a method of approach to a practical study of the Diesel engine, and to chart the course for further and more exhaustive consideration of this new development in response to the demands of operating engineers for a discussion of the fundamentals of the Diesel engine, its application and operation.

Perhaps the question: What is the Diesel engine? should be answered at the outset.

The Diesel engine is an internal combustion engine in which the fuel is ignited by the heat of compression, and is so named because the original inventor of the Diesel principle was Dr. Rudolph Diesel, a German engineer. He observed a simple fact in physics, that compressing air in a closed cylinder raised its temperature, and recognized its relation to the principle of the internal combustion engine. Upon further investigation, Dr. Diesel became convinced that, if the compression in an engine cylinder was carried far enough, sufficient heat would be generated to burn powdered or liquid fuels. He found that if the air is compressed to 375 lb. per sq. in., the temperature of the compressed air would rise to 500 deg. centigrade, and when the fuel is sprayed into such highly heated air, combustion would take place immediately, without the aid of an ignitor or spark plug.

This basic principle is easily explained and can be understood by any one having an elementary knowledge of every-day physics and the ordinary laws of gases as expressed by the pv diagram. While the Diesel cycle can be explained completely only by resort to thermodynamics, involving the use of higher mathematics, the advantages of the heat-conversion process involved can be demonstrated in many practical ways and explained in very simple English. Thermodynamics explains that the theoretical thermal efficiency of a heat engine depends upon the upper and lower temperature limits, the wider apart these temperatures are, the higher the efficiency. If we know the absolute temperature T and T_o, that is, the temperature at which heat is supplied and rejected, respectively, we can express the efficiency as:

$$E = \frac{T - T_o}{T} \text{ or, } E = 1 - \frac{T_o}{T}$$

This means that in the Diesel engine, heat is added at high temperature and rejected or exhausted at low temperature, hence the efficiency is great. In simple words, the Diesel engine, because of its high heat of compression, turns a large quantity of heat into power and wastes only a small amount to the cooling water and the exhaust gases, for by having a high-compression pressure:

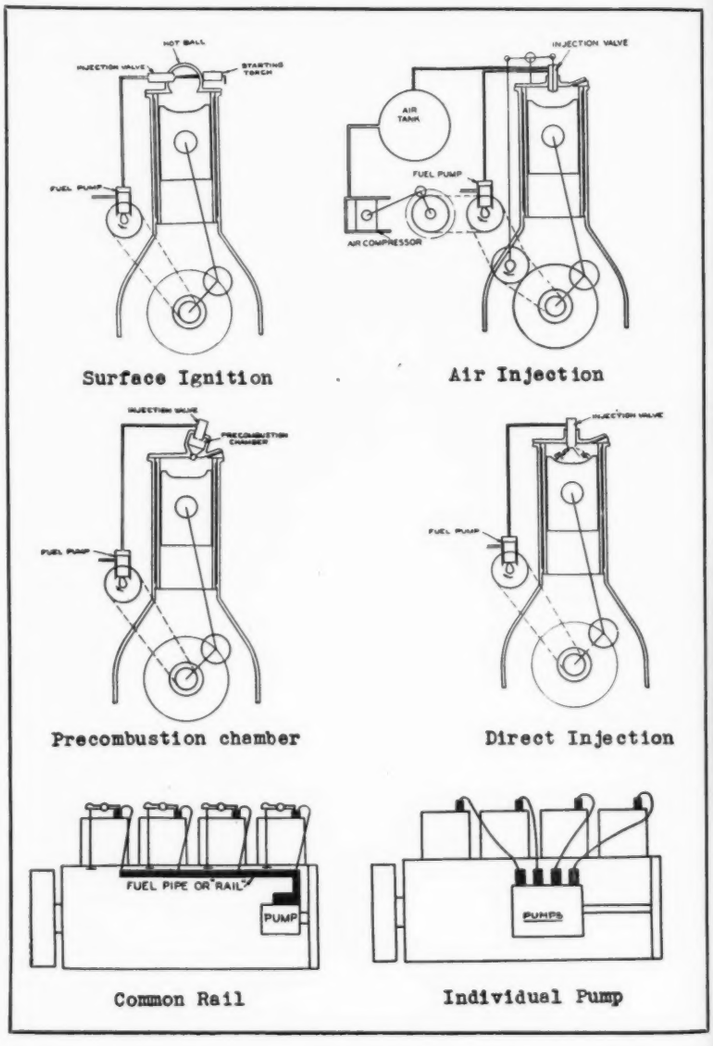

Fig. 1. Classification of engine types

Unretouched Photo, Lease of Major Operator in East Texas Field.

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BEAUTY . . . *Combined with efficiency* . . .

Attractive leases were little thought of until recent years. Now an attractive lease is considered as important as an attractive retail outlet. Oil men have been quick to appreciate the advantages of both.

Lufkin's efficient, trouble-proof equipment lends itself readily to attractive and well-kept leases such as the one reproduced above.

Catalogue No. 36 contains completely illustrated layouts with blue print setting plans and engineering data and will be gladly mailed to oil men anywhere upon request.

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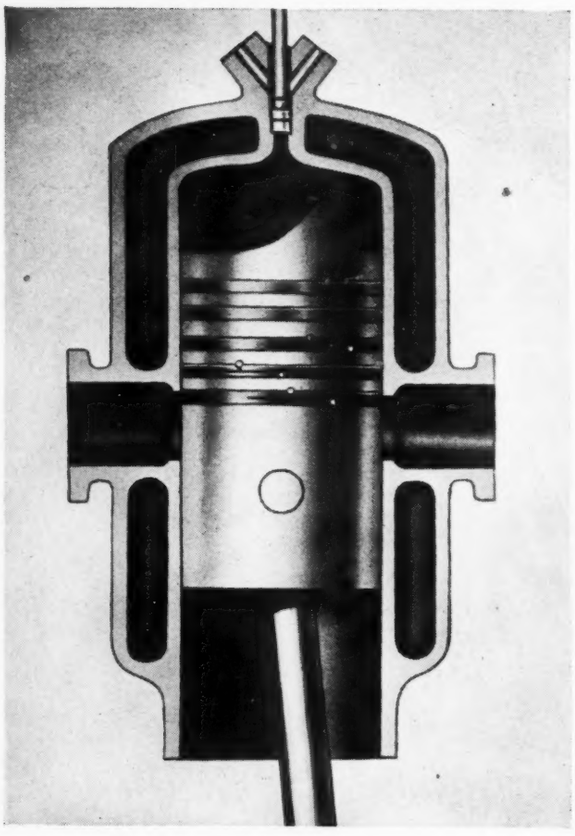

Fig. 2. Two-cycle direct injection type

(1) There is a high initial temperature in the cylinder at the time of ignition and the beginning of the power stroke;

(2) A minimum area of the cylinder is exposed for the absorption of heat to the cooling water, because the piston comes closer to the cylinder head;

(3) More complete expansion of the burning gases occurs, resulting in the release of the exhaust gases at low temperatures; that is, rejecting heat at lower temperatures. The exhaust temperature of the Diesel engine is 30 to 40 percent lower than that of the gasoline engine. Combustion is more complete because of the presence of excess air in the cylinder; that is, the Diesel takes in more air than necessary to burn the fuel used and never has a deficiency of air.

Applications of the Diesel Engine

About the year 1898 the first commercial Diesel engine was placed in use. Shortly afterwards several manufacturers in Europe and America began to construct Diesel engines under the original patents of Dr. Diesel, and for a period of many years only large stationary and marine units were developed. These early engines produced power at a very low cost and competed successfully with other prime movers, many thousands having found a ready market in such applications as isolated power plants, pipe lines, mills, and all types of factories. A total of several million horsepower were built and sold between 1898 and 1933 for these applications, and a high percentage of these engines, including some of the earliest built are still in active and successful service. During more than 30 years constant improvements have been made in the Diesel engine, accompanied by an ever-increasing range of applications and of sizes and types available. (See Tables 1 and 2). No very intensive effort to develop engines intended for the numerous applications filled by the gas and gasoline engine was made in this country until very recently, in fact, it was the late business depression that served to focus attention upon the importance and necessity of ultimate operating economy and lower power cost for every industry.

Types of Diesel Engines Classified

It can be shown that commercial internal combustion engines fall into two general classifications, the Otto cycle, or the ordinary gasoline engine of the spark ignition type, and the Diesel cycle. The principal distinction between the two is mainly the manner in which the fuel is supplied to the engine. In the gasoline engine the fuel is drawn into the engine along with the air, while in the Diesel engine the air alone is drawn in and compressed in the engine cylinder and the fuel later introduced by means of injection. For the purpose of general classification of engine types, it is practical to consider them from the standpoint of ignition (Table 1), that is, it is simpler to classify the oil-burning engine in terms of ignition methods; namely, the spark ignition, the surface ignition, and the compression ignition, or Diesel type. Each of these general classifications may have various sub-classifications, according to the manner by which the fuel is supplied, the method of combustion, the arrangement of the combustion chamber and the type of fuel injection device used. While some engines may be difficult to classify at all, the chart, Table 1, indicates this method of classification for the

TABLE 1

Classification and Sub-Classification of Internal Combustion Oil Engines

I. Spark Ignition
II. Surface Ignition, Hot Bulb (sometimes wrongly referred to as Semi-Diesel)
III. *Diesel*
- *2-Cycle*
- *4-Cycle*
  - Air Injection
  - *Solid Injection*
    - Direct Injection
    - *Pre-Combustion Chamber*
      - Common Rail
      - *Individual Pumps*

TABLE 2

Internal Combustion Oil Engines Classified According to Construction, Design, Operation, and Fuel Injection

4-CYCLE . . .	SINGLE-ACTING	*Trunk Piston*	*Air injection*	*Diesel*
			Airless injection	*Diesel*; *Pre-combustion chamber*; *Hot surface ignition*
		Crosshead	*Air injection*	*Diesel*
			Airless injection	*Diesel*; *Hot surface ignition*
	DOUBLE-ACTING	*Crosshead*	*Air injection*	*Diesel*
2-CYCLE . . .	DOUBLE-ACTING	*Truck Piston*	*Air injection*	*Diesel*
			Airless injection	*Diesel*; *Hot surface ignition*
		Crosshead	*Air injection*	*Diesel*
			Airless injection	*Diesel*; *Hot surface ignition*
		Crosshead; *Sliding Cyl.*	*Air injection*	*Diesel*
	OPPOSED PISTON	*One crank per cylinder*	*Air injection*	*Diesel*
		Three cranks per cylinder	*Airless injection*	*Surface ignition*

International rigid-frame Model TA-40 TracTracTor owned by the White Deer Pipe Line Company, laying pipe in Oklahoma City.

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International Power Unit, burning natural gas, pumping in the East Texas field.

INTERNATIONAL HARVESTER'S long experience as a manufacturer of tractors and power units is the most reliable guide to follow when you need industrial power.

To get the real low-down on International Industrial Tractors and Power Units, trust the men who have put this equipment through its paces. Then you will have a good idea of what International Power can do on your jobs. No matter how tough the work, if it's in International's power range you can expect the utmost in results. And, good as International performance is, it becomes all the better when the cost sheets are figured and you find out about economy.

The International line includes TracTracTors, wheel tractors, and power units, with gasoline and Diesel engines. The power units range in size from 12 to over 100 h.p., and there are light-duty engines from 1½ to 5 h.p. Keep this fact in mind also—no matter where your jobs are, International factory-standard service is close by to keep this equipment on the job. For detailed information, call on the nearby Company-owned branch or authorized industrial dealer.

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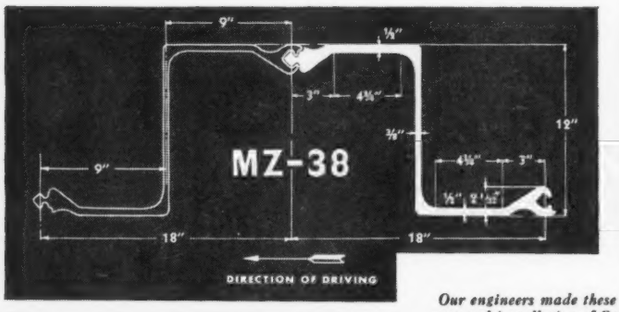
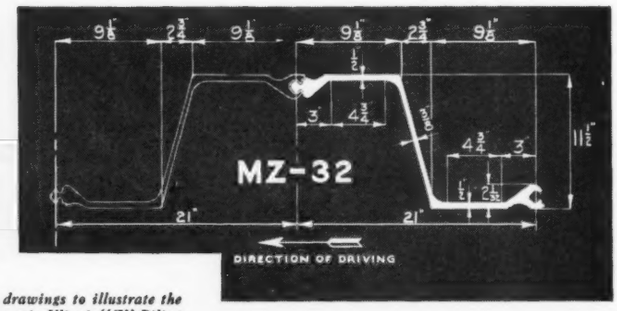
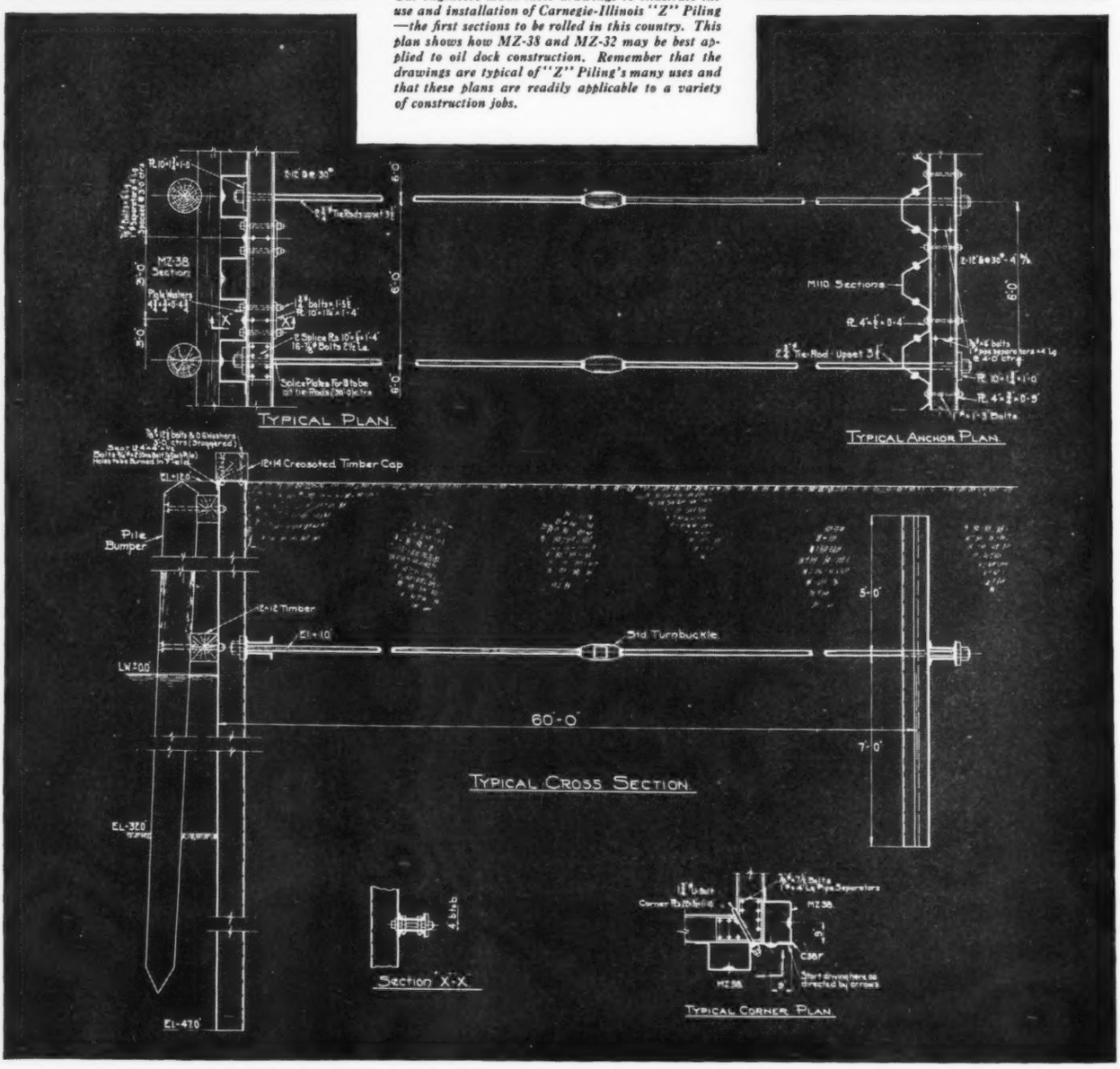
CARNEGIE -ILLINOIS "Z" PILING





Our engineers made these drawings to illustrate the use and installation of Carnegie-Illinois "Z" Piling —the first sections to be rolled in this country. This plan shows how MZ-38 and MZ-32 may be best applied to oil dock construction. Remember that the drawings are typical of "Z" Piling's many uses and that these plans are readily applicable to a variety of construction jobs.



. . . ideally suited to Oil Dock Construction

Offers highest beam strength compared to weight

HERE is a drawing of a proposed installation for oil docks and terminals. It shows why MZ-38 and MZ-32—the first "Z" Piling sections to be rolled in this country—deserve the serious consideration of petroleum engineers.

These new Steel Sheet Piling sections have the highest beam strength compared to weight ever developed. Consider these figures: MZ-38 has section modulus per lineal foot of wall of 46.8 inches^3—*yet weighs only 38 pounds per square foot of wall*, 57 pounds per lineal foot of pile. MZ-32 with section modulus per lineal of wall of 38.3 inches^3 *weighs only 32 pounds per square foot of wall.*

Obviously, either of these new "Z" sections will assure you particularly economical construction for oil docks, wharves, piers, bulkheads, and similar structures retaining heavy lateral loads over long spans.

A sixteen page addition to our Piling Catalog describes these new "Z" sections. Be sure you get a copy. Our engineers are always ready to cooperate with you and will gladly furnish any information you may need.

COMPARE THESE SPECIFICATIONS FOR MZ-38

Area	16.77 ins.^{2}
Driving Distance	18.0 ins.
Weight per lineal foot of pile	57.0 lbs.
Weight per square foot of wall	38.0 lbs.
Moment of Inertia	421.2 ins.^{4}
Section Modulus per pile	70.2 ins.^{3}
Section Modulus per lineal foot of wall	46.8 ins.^{3}

NEW DESIGN INTERLOCK FACILITATES DRIVING, INSURES WATER TIGHTNESS, PRESERVES ALIGNMENT

In this *improved* ball-and-socket interlock, a triangular shaped ball with metal balanced both on ball and socket ends introduces a double locking feature which gives maximum water tightness, reduces tendency of piling to creep and twist in driving, minimizes swing in the interlock, helps to preserve alignment.

Further, the concentration of metal in the triangular-shaped ball greatly reinforces ball against curling during hard driving and facilitates the use of long sections in hard bottoms.

INTERLOCK WELDING UNNECESSARY

Interlocks are located where longitudinal shear is zero—the section modulus of the single uninterlocked pile is thus the same as when interlocked. No welding of interlocks is necessary to prevent slippage due to longitudinal shear.

RUGGED TO RESIST BATTERING

Note the heavy concentrations of metal at the four exposed points. They stiffen the pile against battering, make it especially suitable for deep water structures.

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UNITED STATES STEEL

Table 3
Classification of Internal Combustion Engines

Engine Type	A	B	C	D	E	F
Spark Ignition						
Surface Ignition	X					
Compression Ignition		X	X	X	X	X
Two-Cycle or Four-Cycle	2		4	4	4	4
Air Injection		X				
Solid Injection	X		X	X	X	X
Direct Injection		X		X	X	X
Pre-Combustion Chamber	X		X			
Common Rail					X	
Individual Pump	X	X	X	X		X

purpose of identifying the type and class of engine in question. By this means engines can be intelligently studied for the purpose of determining the application and suitability to a given service.

Spark Ignition Type

Engines of the spark ignition type are low-compression engines and may be either the ordinary gasoline engine with carburetor, or engines adapted to burning Diesel fuel oil that is injected by means of a fuel pump but ignited by means of a spark plug, and after being started, operate on fuel oil and spark ignition. The heat of the exhaust is employed on some engines of this class to aid the vaporization of the fuel oil. Some engines of this type are conversions from the gasoline engine, others are specially designed to burn low-price fuels in low-compression cylinders and still retain the advantages of low-cost construction of the low-compression gasoline engine. While this type of engine has been highly developed by at least one designer, many other attempts to build this kind of engine have not been very satisfactory, on account of the low compression, which causes serious difficulty with the lubricating contamination. Such engines do not give good service with variable load and at idling speed and the power output has usually been very low in relation to engine size.

Surface Ignition Type

Many engines of this type were built during the early period of Diesel history, and like the spark ignition engine, are not true Diesel engines. They are called "hot bulb", or surface ignition engines, and are frequently but incorrectly called "Semi-Diesels." In this type of engine, ignition of the fuel is not dependent entirely upon the high compression, but is aided by the residual heat of the bulb or hot plate in the combustion chamber. Since lower compression pressures are employed in these engines than in the full Diesel type, it is necessary in starting these engines to apply heat by means of a torch or other external means to heat the hot bulb or plate to assist in initiating ignition. After the engine is started, the high temperature of the hot bulb is maintained by subsequent combustion. Such engines give good performance at constant loads and speeds, but are not well suited to variable loads and idling is very poor, the bulb cooling down and causing the engine to miss firing; moreover, this principle of ignition makes the power output for given size of cylinder too low to be very satisfactory in the high-speed engine applications where variable load and speed requirements are a characteristic. The difficulties of employing externally applied heat in starting, and the difficulties of maintaining, under varying loads and at idling speeds, sufficient heat of the bulb or plate to give reliable ignition restrict this engine to stationary and other applications where the load and speed are fairly constant.

This type of engine established great records for dependability and economical operation in the moderate power applications of the stationary type, and was extensively employed in marine service for many years before the Diesel engine was developed for the intermediate and small power applications, particularly before solid injection supplanted air injection on large slow-speed engines.

Diesel or Compression Ignition Type

The true Diesel type engine, referred to as the "full" Diesel to distinguish it from the "Semi-Diesel," or Surface Ignition, type of engine is now recognized as more desirable to meet the great number of applications now demanding the economy of the oil-burning engine. There are two methods by which the fuel is supplied to this type of engine, namely, the air injection and the solid injection of the fuel. The principle of air injection —the blowing of the fuel into the cylinder by a blast of highly compressed air, requires compressed air at a pressure of approximately 1000 lb. per sq. inch. While this method of introducing fuel into the cylinder was used almost exclusively by the early slow-speed stationary engines, its use on high-speed engines and on modern Diesel engines for a great variety of applications is not practical or feasible, since the air injection method requires the use of a three-stage air compressor and high-pressure air receivers. The use of such compressors and the difficulties of

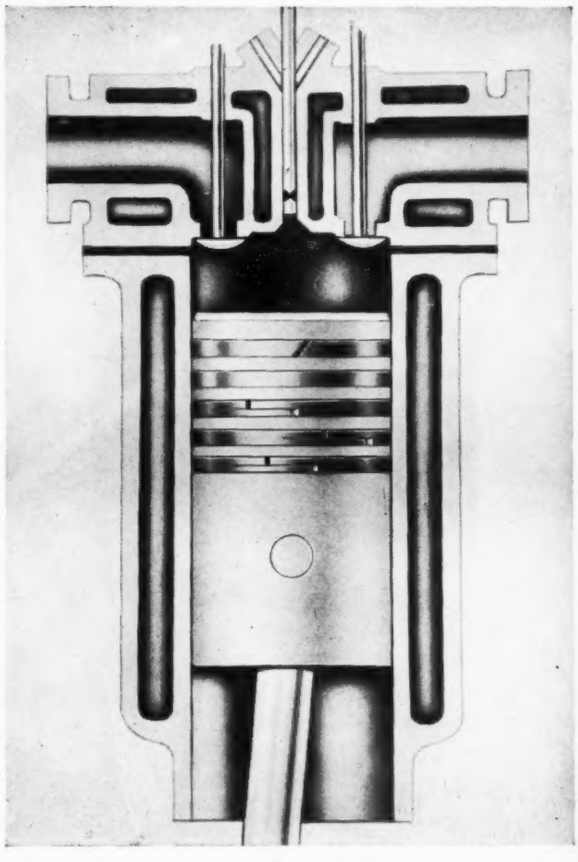

Fig. 3. Four-cycle direction injection type

IDEAL

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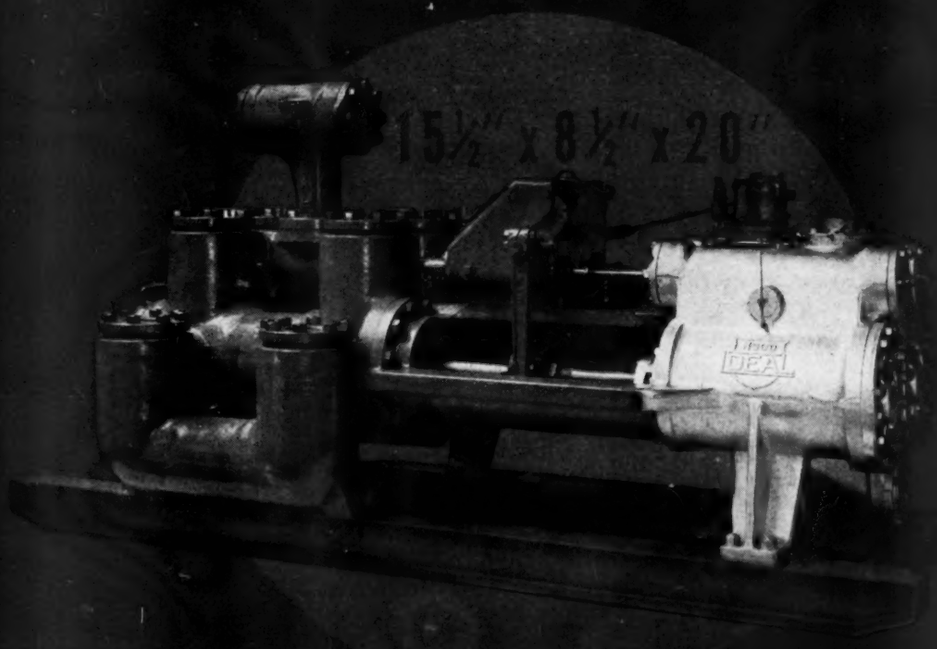
STEAM SLUSH PUMP



Descriptive Bulletin No. 68, giving complete description of this pump, will be mailed upon request.

Automatically lubricated, totally enclosed, patented rock shaft stand—a distinct feature of design contributing to the extraordinary performance of this pump in the heaviest of drilling service.

THE NATIONAL SUPPLY COMPANY

National

preventing air leaks in many mobile applications is avoided by employing the solid injection method, sometimes called "airless injection" method of fuel injection, a method that consists of keeping the fuel in a solid stream up to the point of injection by pump pressure through injection nozzles.

As indicated in the classification chart, there are two classes of engines using solid injection, the direct injection type and the pre-combustion chamber type. Each of these types has been successfully developed and each has points or merits that have found favor by Diesel designers and users. The direct injection type, in which the fuel is introduced directly into the combustion space or the cylinder possesses the virtue of great simplicity of construction and has a slightly better fuel economy than the pre-combustion type of engine.

The pre-combustion type of engine is extensively employed in the high-speed field, while many engines designed for larger applications and slower speed are of the direct injection type.

The pre-combustion type of engine is less sensitive to fuel conditions, and is comparatively free from difficulties associated with direct injection or open-type combustion chambers. It has been found to give uniformly good results under varying load conditions; complete combustion and clean exhaust are obtained and excessive heat stagnation in the piston head and contamination of the lubrication oil is prevented because the oil on the cylinder walls does not come in contact with the injection spray. The fuel is first introduced into a small pre-combustion chamber where it is ignited and passes through a restricted neck into the cylinder proper while in a state of ignition. The several advantages are that this type of engine employs a lower injection pressure, makes use of a single, comparatively large injection orifice instead of the multiple orifice injection nozzle with small holes that readily stop up. This assures better ignition under all loads and speeds, and there is less ignition delay and more complete combustion.

Individual Injection Versus Common Rail System

The solid injection engine, whether pre-combustion chamber or direct injection into the open combustion chamber, may employ either the common rail system or the individual pump method of injecting the fuel. In the common rail system, known as the constant pressure type of injection device, a single pump unit supplies the fuel to a pipe or rail that carries the fuel under constant pressure. From this pipe or rail, which acts as an accumulator, the fuel is fed to each cylinder by mechanically operated and cam-controlled valve mechanism. The chief objection to the common rail system is the difficulty of adjusting the fuel apparatus so that the engine will idle without missing in any cylinder. When the quantity of fuel to be injected is reduced to a small amount for idling speed, one or more of the cylinders receives no fuel, while some of the cylinders receive sufficient fuel to keep the engine running. This does not occur on the large slow-speed engines, but is difficult to avoid in the modern high-speed applications. It is also desirable in the later type to eliminate the high pump pressures associated with the common rail system, and for general service a simple, more dependable, and uniform action fuel injection system is desired.

The individual pump type is an answer to this problem. In this system an individual pump is used for each cylinder, and in many cases each pump is a separate individual unit, which can be removed for servicing and adjustment.

It is evident that the Diesel engine possesses great flexibility of design, and possibilities for application on a great variety of conditions. It is likewise obvious that the fundamental operating requirements determine the design and the suitability for a particular application. In Fig. 1 is shown a group of engines diagrammatically illustrated and conforming to the classification and subclassification discussed here and outlined in the chart, Table 1. A study of this chart and the diagrammatic illustrations of elementary engines afford a basis for practical classification of almost any type of engine and its suitability for a given application. The chart, Table 2, shows the more general classification according to construction and general design, the classification applying to the whole range of Diesel engines in the larger slow-speed class, while Table 1 shows the limits of the high-speed design. Table 3 classifies the types of engines shown in Fig. 1:

A=Surface Ignition				B=Air Injection		
C=Precombustion Chamber				D=Direct Injection		
E=Common Rail				F=Individual Pump		
Cooling oil condensate	. . 3,458,000	31	300	28	73	1690

An analysis of any engine application or any engine type may be made in this manner and the engine considered from the standpoint of design, operation, and application.

In Figs. 2 and 3 are shown the two-cycle and four-cycle direct injection types, respectively. A small modern Diesel is shown in Fig. 4, in which also is shown a cross-section of the combustion chamber.

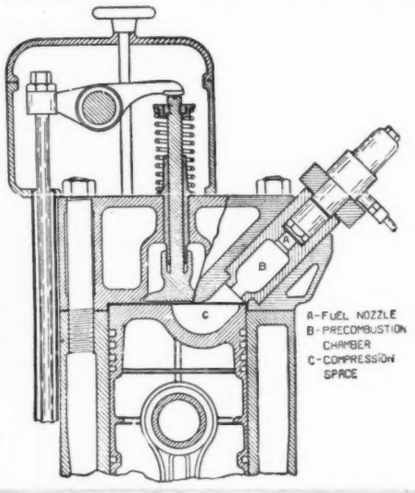
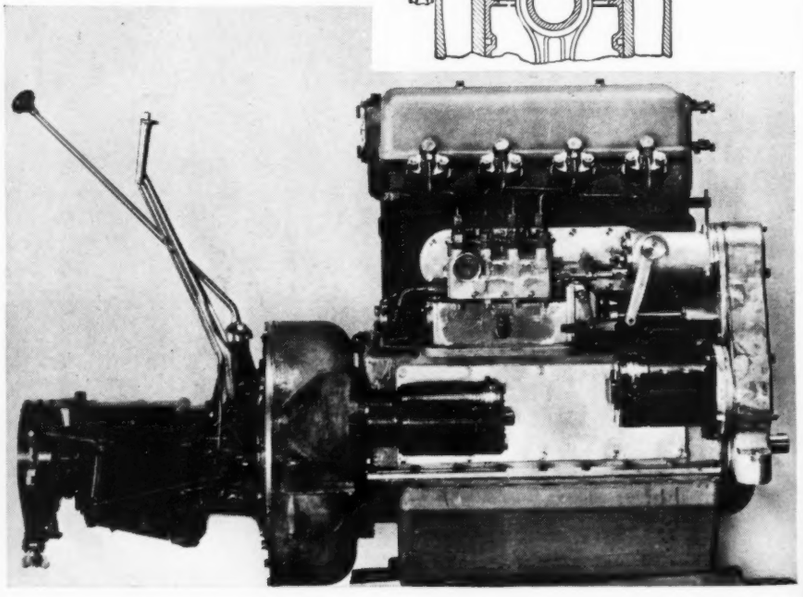


Fig. 4. Below: Four-cycle Diesel, solid injection, individual pump, pre-combustion chamber, compression ignition engine. At right: Combustion chamber section.



Instrument for Locating Coating Faults and Corroded Areas on Pipe Lines

By A. L. SMITH*

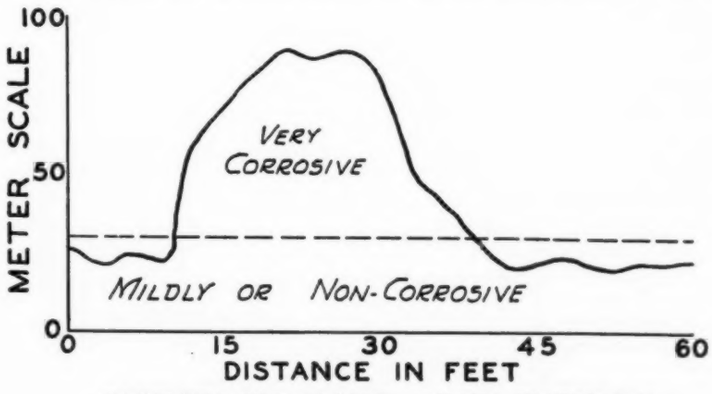
FOR the purpose of locating faults in coatings and determining corroded areas on uncoated pipe line in the ground without the necessity of uncovering the pipe, an instrument, known as the Faultometer, has been developed. Recent tests have been made in the Gulf Coast area on lines of the Humble Pipe Line Company and the United Gas System.

This precision instrument (through means of flux density), will indicate abrasions or holidays on coated lines, corrosive areas on bare or uncoated lines, or such areas on proposed pipe line right-of-ways. This is accomplished by readings taken on the ground surface. The instrument is composed of a high-frequency current generator that imposes current onto the pipe line by making one contact to the line and the other to a ground rod some distance away. On Coated lines the current flows at points of holidays and abrasions. An intense flux field is established directly above the abrasions, extending to the ground's surface. The receiving or measuring instrument is carried by the operator, and by engaging the ground surface at short intervals along and above the pipe line with an electrode arrangement attached to the measuring instrument these small flux fields are encountered, indicating abrasions in the coating. The flux density is indicated on the instrument meter scale reading o to 100. he sensitivity of the instrument is extremely high, but is controlled in arbitrary steps. Readings are relative and may be read using a large or small differential.

The Faultometor in Use

The generator or transmitter connections remain the same when the instrument is being used for determining corrosive areas or "hot spots" on bare or uncoated lines. Readings are taken in the same manner as when detecting abrasions in pipe coatings. The differential in readings between non-corrosive and corrosive soils is a little less than that obtained between an abraided area and a well-coated section of line, as a comparison so far as differential is concerned; however, relativity is somewhat higher. Intense flux fields are established in corrosive areas, being of a much higher intensity than in a non-corrosive area.

In using this instrument to make a corrosion survey of a proposed pipe line right-of-way, the generator or transmitter connections are made to two ground rods placed parallel to the right-of-way and spaced ten or more feet to either side. The operator contacts the soil in the right-of-way with the receiving and flux measuring instrument and readings are taken every few feet.



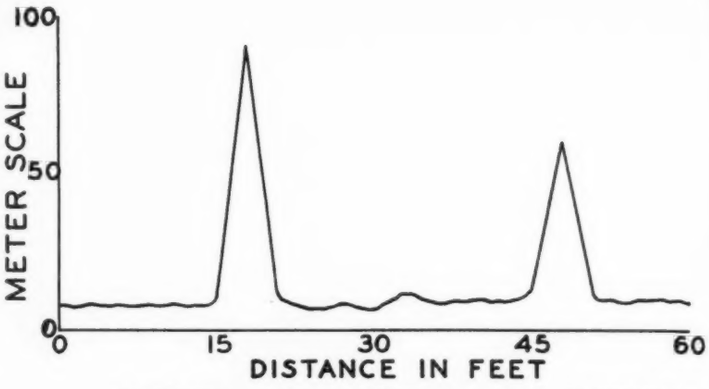
SURVEY OF BARE LINE SHOWING SMALL CORROSIVE AREAS

The Faultometer also may be used for determining the best location for ground beds, used in cathodic protection. For the most efficiency in cathodic protection, it has been found desirable to place the ground bed for the positive side of the circuit opposite the

*Crutcher-Rolfs-Cummings, Inc., Houston, Texas.

best coated section of line within the area proposed to protect. This is done in order to obtain the utmost distribution of current and to prevent extreme saturation of current opposite the ground bed. The Faultometer is used to indicate the best section of line for this purpose.

Another use is indicating the location of existing leaks on bare line that do not visually show on the ground's surface. Some companies are troubled with this problem to a certain extent. Oil leaking from the line in a case of this kind generally follows a crevice or crack at pipe line depth, goes off the right-of-way and then makes itself known by showing up in a crack or some low point a considerable distance away. Sometimes considerable loss of oil, time, and expense result before the origin point of the leak is found. The Faultometer indicates leaks of this nature and collar "sweats" that do not show, if the instrument is used in the same manner as in checking for corrosive areas on bare lines. Oil saturating the soil around the line tends to act as an insulating coating at these points. Readings obtained opposite bare pipe, thus showing a large differential and indicating the origin point of such leaks.



SURVEY OF COATED LINE SHOWING HOLIDAYS IN COATING

Experiments now indicate that this new principle may be applied in determining the geological nature of strata and eliminating continuous coring in the drilling of a well; likely other uses also will be found

The outstanding use at present is for spot reconditioning on both coated and uncoated pipe lines, as described, making possible reconditioning programs at a minimum expense, resulting from application of pipe protection only where needed.

Two Belt Lap Kinks

By W. F. SCHAPHORST

THERE is an old rule regarding the "correct way" to run belt laps that does not take into consideration the fact that on one pulley the belt slips in *one* direction and

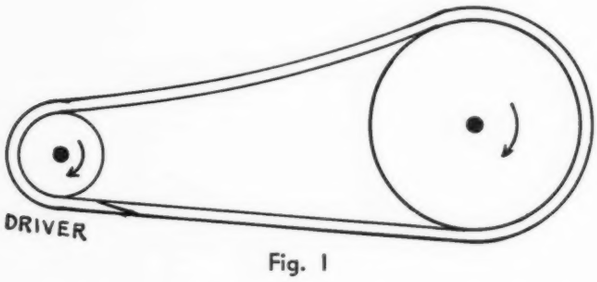


Fig. 1

on the other pulley the slip is in the *opposite* direction. Slipping and creeping are always toward the *tight* side of the belt. Thus on the small pulley, Fig. 1, the slip will be such as to "smooth" the scarfed edge of the joint, while on the large pulley the tendency is to open the joint and cause the feather edge of the lap to roll up.

The proper rule, in a case of this kind, is: "Make the small pulley the determining factor." That is, let the small pulley do the "smoothing." The large pulley is less likely to cause opening and rolling-up of the lap. Or, in some instances it may be possible to make use of the kink illustrated by Fig. 2. This sketch shows how, by simply giving one end of the belt a half turn, the tendency will be to "smooth" the joint on both pulleys—which is as it should be.

For wide belts on pulleys that are close together this method is not recommended, but for narrow belts it is all right. Also it gives good results on wide belt drives with pulleys far apart.

Another advantage of a belt turned in this manner is that each pulley has its own side of the belt to work on. That is, the flesh side will always be in contact with one of the pulleys and the hair side will always be in contact with the other pulley. Projecting belt fibres therefore are not first bent and rubbed in one direction and then in the other direction, an action that may cause rapid wear. The fibres on both sides of a single belt will lie always in the same

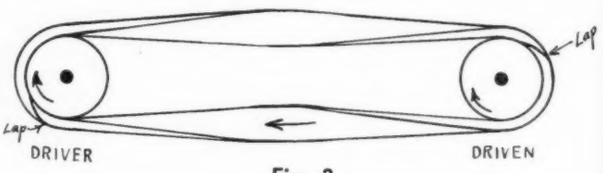


Fig. 2

direction as the lap—a condition that is ideal. This advantage holds whether the belt is single, double, or triple, and whether it is leather or fabric.

Effect of Corrosion on Coated and Uncoated Pipe Lines

AN interesting comparison of the effect of corrosion on coated and uncoated pipe lines is afforded by data recently compiled by three major pipe line companies. The companies, which for the purposes of this article will be designated as Company No. 1, Company No. 2, and Company No. 3, (the latter two affiliated) each laid an 8-in. screwed line in 1917 in approximately the same areas of northern Texas and southern Oklahoma. Late in 1935 the pipe was taken from the ground and the usable portions salvaged and relaid into a new line. When originally laid the lines of Company No. 2 and Company No. 3 were coated with asphalt and wrapped with saturated felt. Company No. 1 used no protective covering. As the pipe was taken up and reconditioned detailed records were kept of its condition and usableness.

The accompanying table shows the volume of pipe recoverable, the amount that had to be spot-welded and otherwise reconditioned prior to use, the percentage it was necessary to junk, etc. It will be noted that in Company No. 1's uncoated line 8.37 percent of the pipe was junk, while of Company No. 2's section of the line 4.2 percent was junk, and of Company No. 3's section 0.36 percent fell into that classification. Considering the latter two companies' sections together, inasmuch as they are affiliated, the percentage of junk pipe was 3.75.

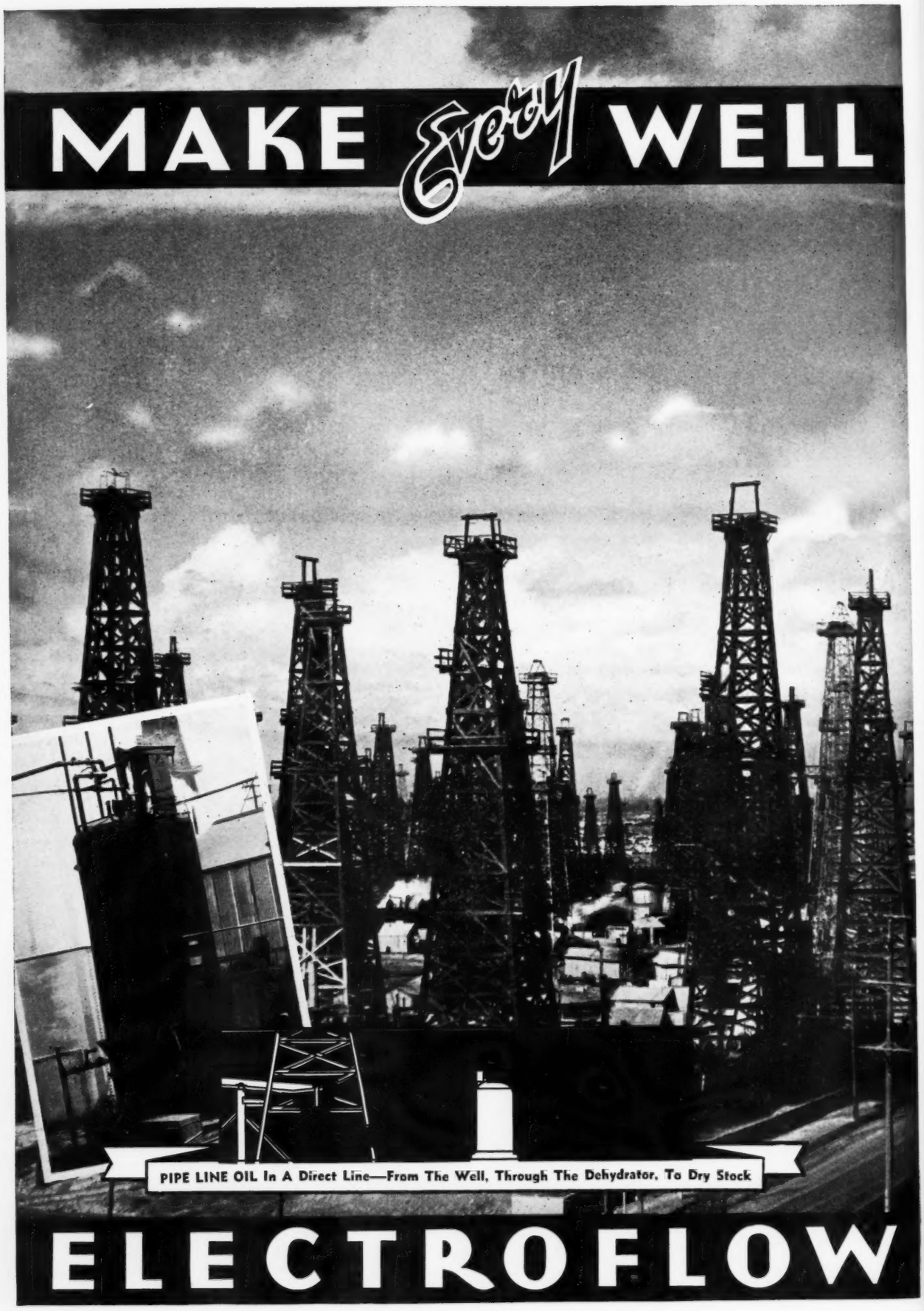
From Company No. 1's line (uncoated), 46.12 percent of the pipe was first grade quality without spot-welding; and from the combined lines of Company No. 2 and Company No. 3 (coated) the recovery on the same basis was 87.7 percent. Company No. 1 was able to make an additional 18.02 percent of its pipe come up to grade one by spot-welding. Company No. 2 brought an additional 6.63 percent of its pipe up to first quality by the same method, but none of the pipe of Company No. 3 required spot-welding. The total volume of first grade pipe recovered by Company No. 1 was 64.14 percent, while the total for the other two companies combined was 93.5 percent. In addition to the first grade pipe Company No. 1 reclaimed 24.76 percent of pipe that was not of sufficiently high quality to re-lay in the new line but, nevertheless, was usable.

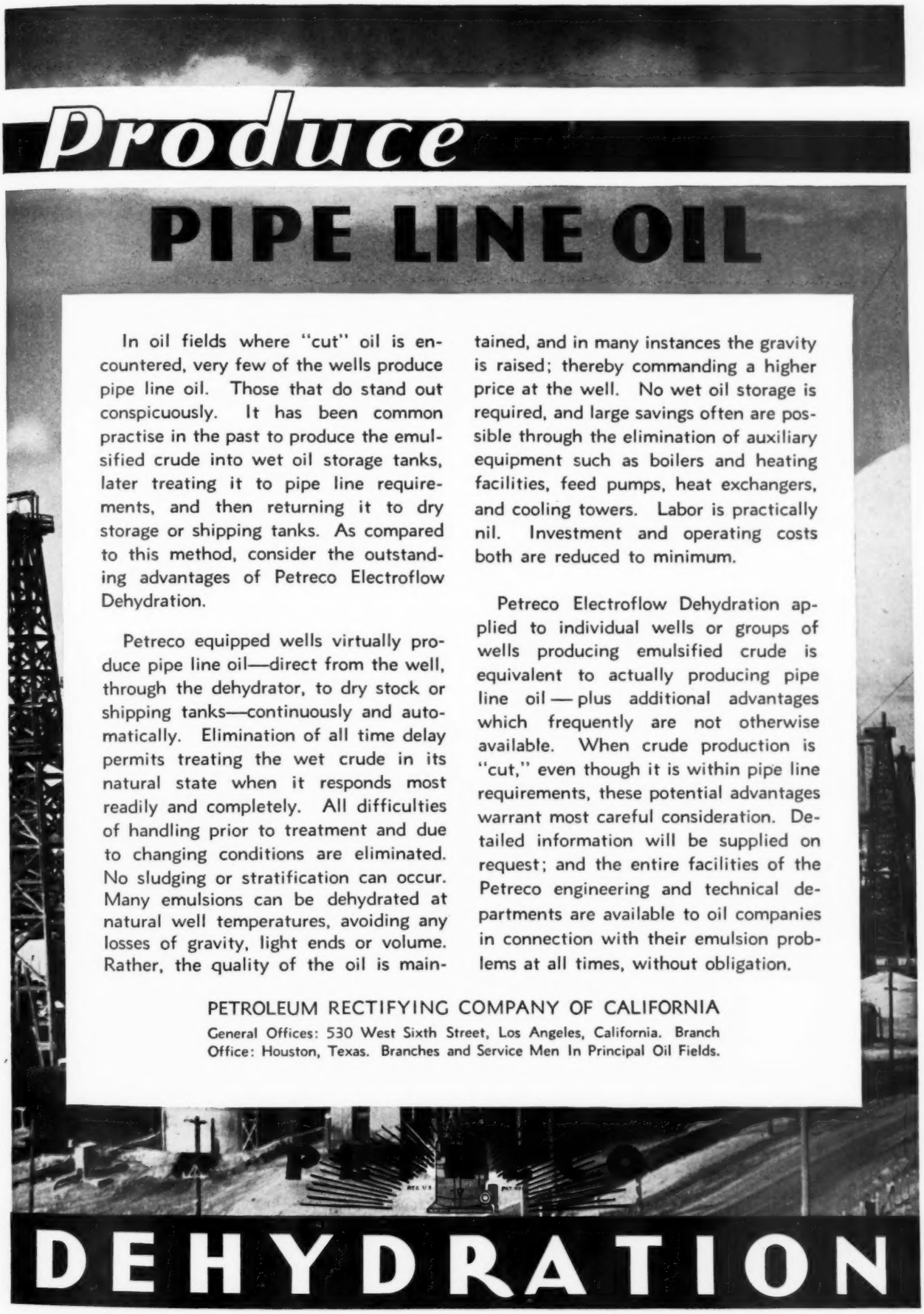
Due to its condition, pipe taken from the line of Company No. 1 was found to require a greater amount of cleaning than that taken from the other lines. On the former cleaning equipment was a W-K-M doublehead machine, first used on the pipe over the ditch as it was raised from the ground, and an inspection was made immediately behind the machine. The contractor on the job decided, however, that it would be more economical to clean the pipe in a central yard. The machine, therefore, was set up in the reconditioning yard and the pipe cleaned as hauled in. Considerable difficulty was encountered on portions of the pipe due to adhering clay, sand, and scale, and in some instances, it was necessary to run a stream of water over the cutters while the machine was in operation. A small volume of pipe was cleaned that had been given a high-melting-point coating of bitumen in 1929. This was run through the machine during cool weather without any special difficulty being encountered.

STATEMENT OF PIPE RECOVERED FROM LINES IN NORTHERN TEXAS AND SOUTHERN OKLAHOMA

	Company No. 1		Company No. 2 and Company No. 3 (combined)		Company No. 2		Company No. 3	
Location of line	Love County, Okla., and Cooke County, Tex.		Love County, Okla.' and Grayson County, Tex.		Grayson County, Texas		Love County, Oklahoma	
Size and type of line	8 in screwed		8 in. screwed		8 in. screwed		8 in. screwed	
Length of line	44.6 miles		36.7 miles		32.4 miles		4.3 miles	
Protective coating	None		Asphalt and saturated felt		Asphalt and saturated felt		Asphalt and saturated felt	
Date lines laid	1917		1917		1917		1917	
RECOVERY	Ft.	Percent	Ft.	Percent	Ft.	Percent	Ft.	Percent
Pipe acceptable for re-use without spot-welding	108,747	46.12	169,716	87.7	147,767	86.52	21,949	96.62
Pipe acceptable after spot-welding	42,491	18.02	11,320	5.85	11,320	6.63	.....	.....
Pipe usable but not of sufficiently high grade for shipping to lay in new line	58,390	24.76	.....	.....	.....	.....	.....	.....
Junk pipe taken up	19,450*	8.25	5,722	2.96	5,640	3.31	82	0.36
Pipe abandoned in place	278	0.12	1,532	.79	1,532	.89	.....	.....
Total junk (sum of above two items)	19,728	8.37	7,254	3.75	7,172	4.20	82	0.36
Threads cut off, recuts, etc.—Loss in reclaiming	6,444	2.73	5,213	2.70	4,527	2.65	686	3.02
Total	235,800	100.00	193,503	100.00	170,786	100.00	22,717	100.00

*Part of this was cleaned and part not cleaned. Amount shown includes 3,028 ft. of pipe that was reconditioned and given protective coating in 1929.


MAKE Every WELL
PIPE LINE OIL In A Direct Line—From The Well, Through The Dehydrator, To Dry Stock
ELECTROFLOW



Produce PIPE LINE OIL

In oil fields where "cut" oil is encountered, very few of the wells produce pipe line oil. Those that do stand out conspicuously. It has been common practise in the past to produce the emulsified crude into wet oil storage tanks, later treating it to pipe line requirements, and then returning it to dry storage or shipping tanks. As compared to this method, consider the outstanding advantages of Petreco Electroflow Dehydration.

Petreco equipped wells virtually produce pipe line oil—direct from the well, through the dehydrator, to dry stock or shipping tanks—continuously and automatically. Elimination of all time delay permits treating the wet crude in its natural state when it responds most readily and completely. All difficulties of handling prior to treatment and due to changing conditions are eliminated. No sludging or stratification can occur. Many emulsions can be dehydrated at natural well temperatures, avoiding any losses of gravity, light ends or volume. Rather, the quality of the oil is maintained, and in many instances the gravity is raised; thereby commanding a higher price at the well. No wet oil storage is required, and large savings often are possible through the elimination of auxiliary equipment such as boilers and heating facilities, feed pumps, heat exchangers, and cooling towers. Labor is practically nil. Investment and operating costs both are reduced to minimum.

Petreco Electroflow Dehydration applied to individual wells or groups of wells producing emulsified crude is equivalent to actually producing pipe line oil — plus additional advantages which frequently are not otherwise available. When crude production is "cut," even though it is within pipe line requirements, these potential advantages warrant most careful consideration. Detailed information will be supplied on request; and the entire facilities of the Petreco engineering and technical departments are available to oil companies in connection with their emulsion problems at all times, without obligation.

PETROLEUM RECTIFYING COMPANY OF CALIFORNIA

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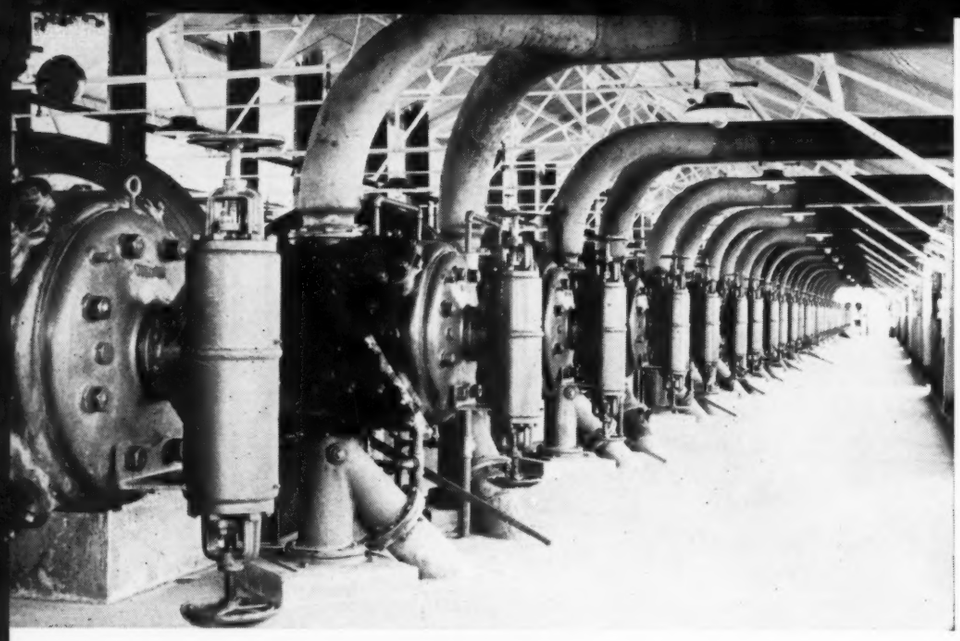
DEHYDRATION



Interior of engine room showing first 15 units in operation, Clark Brothers' 250-hp. super-2's with 17-in. cylinders on either end

By
J. C. ALBRIGHT

Handling Casinghead Gas in Capitol Extension of Oklahoma City Field

Although wells are being drilled in the area at "fever heat," conservation of the gas produced with the oil is not being overlooked — Following recovery of natural gasoline, the residue gas is being utilized for repressuring in older areas of field, and for drilling.

A RACE to complete wells in the "Mansion Pool" of Oklahoma City also includes a race to conserve and utilize the gas produced with the oil. Bottom-hole and shut-in pressures are both abnormally low in that area, considering the potential production of the wells already completed. Many of the wells now on production have a separator pressure that is sufficient to transport the gas several miles without the use of compression; but many wells are expected to flow at pressures so low that it will be necessary to utilize gas-engine-driven compressors to handle the gas from the traps and separators and deliver it to the older area in the southeast part of Oklahoma City, there to be processed for the recovery of natural gasoline. Much of this gas will be used in lifting oil from the more depleted zones in the older areas of the Oklahoma City field, and a sufficient amount returned to the area north of the Capitol for fuel while drilling additional wells to the Wilcox.

Phillips Petroleum Company, the largest manufacturer of natural gasoline in the Oklahoma City field, is undertaking the huge task of gathering, compressing, stripping, and returning gas throughout the field. Several compressor stations have been in operation by this company to boost gas from one part of the older field to another, and in one plant as much as 335,000 gal. of natural gasoline has been manufactured in 24 hours. Because of the extremely large volume, two wet gas lines have been laid to handle the gas from the numerous wells being drilled in the "Mansion Pool," one through the heart of the exclusive residential section, known as Lincoln Terrace, and the other through the extreme east side on the edge of the city. These two lines are of spiral-welded pipe, 24 in. in diameter; one line at present is used to transport gas compressed by a battery of gas-engine-driven compressors and the other to transport gas by trap pressure until such time as flowing conditions make it imperative that the gas be handled by compressors.

The compressor station, part of which has been completed, will contain 28 twin gas-engine-driven compressors with 17-in. power cylinders equipped with pressure fuel injection. The engines are new equipment, with the exception of the gas compression cylinders, which have been reconditioned by reboring and having new pistons and rings fitted to them. The building housing the engines was planned so that the power plant would contain two units, the first having 15 compressors, with two auxiliary engines and the necessary water pumps, and the second to consist of 13 compressors, with the auxiliary equipment serving both units.

The first unit, or section of the compressor station, has been completed and is handling gas at the rate of about 80,000,000 cu. ft. per day, and after the entire compressor station has been completed, approximately 150,000,000 cu. ft. of gas will be compressed daily when operating at full capacity. This volume of gas will be taken from wells that cannot be produced with a high back pressure, and passed through the line traversing the extreme east side of the city. Gas that can be taken from the traps and separators at a pressure greater than 50 lb. will be transported through the second 24-in. line traversing Lincoln Terrace.

City regulations to be complied with in Oklahoma City are many and varied when it comes to laying a pipe line through the residential section, such as Lincoln Terrace. For instance, when a permit was obtained enabling the contractors, Williams Brothers, Inc., of Tulsa, to begin operations, an

Phillips Petroleum Company's Mansion compressor station north of Oklahoma State Capitol

ordinance was found that prevented the use of machinery for digging ditches. Another ruling prevented the use of tractors having the usual flat steel treads attached to the self-laying tracks, and wood blocks were required instead. After all the equipment for protecting the street surfacing was attached to these tractors, it was discovered that the tractors could be operated only in a straight line, to be turned around upon platforms, or backed out of the district for turning.

The nature of the top soil and subsoil in Oklahoma City is such that only the Red Beds were penetrated. These contain medium hard rocks, all of which can be penetrated with air-operated spades and pavement breakers. Although drag-line hoes were used wherever possible to remove the broken-up rocks from the ditch, practically all the material was removed by pick and shovel. Had these lines—one a 24-in. spiral-weld pipe for wet gas and the other a 12-in. for returned residue—been laid through the usual agricultural or ranching country, motorized equipment could have been utilized, and where hard rock was encountered, explosives employed to loosen it; but the multiplicity of city ordinances and rulings prevented the use of anything but hand labor, with few exceptions.

Existing lines below the surface of the ground, such as water, gas, and sewer mains, together with electrical and telephone conduits, made it necessary to lay these two gas lines below all others. The criss-cross pattern of the city service lines resembled a Chinese puzzle and prevented handling long lengths of pipe; and many times it was necessary to skid a single joint of either the 24-in. or 12-in. pipe end-first beneath those already in the ground. Driveways leading from the streets to the homes along the pipe line right-of-way in many cases had to be cribbed with heavy timbers while the lines were being placed in position.

The length of the right-of-way is only some three miles where it crosses from the Mansion Pool to one of the gasoline plants near the North Canadian River, but the estimate called for about 700,000 cu. ft. of excavation. All the rock excavated was handled twice, once in removing from the ditch, and once while back-filling after the line was laid, the excess being carried away in trucks. Sod was carefully removed from the top soil when the ditchers began the excavation, and after tamping the surface of the ditch the top was resodded to prevent an unsightly appearance.

Where it was possible to place more than a single joint in the ditch at one time, welders were employed in joining the usual lengths to others beside the curb by using arc-welding machines mounted upon trucks. The final operation, so far as welding was concerned, was the spotting into the pipes of connections for well hook-ups and service connections in the residue line for the removal of drilling fuel. Connections for these purposes were made up prior to welding, and were ready to be connected by the welders when delivered to the pipe lines.

The bottom of the ditch was not of a uniform and continuous grade; that is, parts of it were much lower than others because of the existing lines in the ground. Parts of the line therefore dipped downward and in a short distance, sometimes within the length of a joint of pipe, the bottom of the ditch became more shallow after the obstruction was passed. These conditions made it necessary to make bends in the pipe; these were made by cutting the ends of the pipe at the desired angle and joining by welding. As the gas, both raw and residue, does not contain an excessive amount of

Preparing to lower 24-in. spiral pipe in ditch with Caterpillar Diesel tractors. This view taken at 21st and Kelly southeast of Governor's Mansion

liquids, drips were not placed at these low points, the velocity of the flow through the lines being depended upon to prevent pocketing.

Loops have been laid from the compressor station to this pressure line so that when the flowing pressure subsides, gas can be transported by recompressing it and then used as in the case of the first line laid from the Mansion Pool. Provisions have been made at the compressor station to handle any volume of gas up to the capacity of the 28 machines without any appreciable pressure drop from the separators to the intake of the gas compression cylinders. Headers have been laid in the plant, supported upon steel and concrete supporting structures so they will be above the surface of the ground.

The discharge header has been laid as one continuous line, made from 24-in. welded pipe, manufactured by A. O. Smith Corporation. The intake line has been made up with the same size and kind of pipe, one header running the full length of the compressor room, and the second one tied in so that a sufficient volume of gas can be utilized for compression without starving some of the engines at the expense of others. As the station is on the extreme east side of the "Mansion Pool," suction is taken from the west end of the row of engines. The looped suction line parallels the building, with the service line extending the full length, but the second extending eastward to a point opposite the ninth compressor, where it is joined to the first. This arrangement provides for approximately the same suction service as if lines entered the compressor station from both the east and the west.

Suction from the intake headers is obtained by running piping overhead from outside the compressor room building to the top of the compressor cylinders, one line serving each twin engine, and the branched line parting just above the engines. Long pipe bends and welding ells have been employed to reduce the pressure drop from the header to the intake valves of the compressors with the control valves placed on the risers just above the header. Likewise, the discharge, after being attached to the compressor stool, converges into a common line that lies under the surface of the floor and the soil outside, where it is attached to the bottom side of the header. The control valve for this service has been placed at a point so the operator can manipulate both the intake and discharge from one standing position.

A large line has been laid beside the intake header to serve as a relief line, which carries gas from the header and intake assembly when changing the operation of the engines, such as shutting down and placing in service. The discharge line leading from each twin engine is equipped with a single relief line attached to two safety valves, operated either by pressure or by manual control. These safety valves are placed upon a loop and extend high enough so that an operator may open one or both without moving from his position when he finds it necessary to operate either the intake control valve or the discharge valve. A steel grating walk is laid between the intake header and the relief line for the convenience and safety of the operator when it becomes necessary for him to control the operation of the engines from this point.

Another innovation found in this compressor room consists of using a single muffler for two power cylinders. Usually where cylinders are placed in an inverted position, each is equipped with an individual exhaust pipe terminating in a muffler above the engine room roof, but in this station the exhaust pipes from each cylinder of a twin engine converge above the roof and join a single large muffler. There is the usual jacket on the exhaust pipes to prevent the radiation of heat from the pipes to the air in the building.

Gas leaving the discharge valves of the compressors is led through the header outside the building to conventional atmospheric cooling sections placed in a louver tower to reduce the heat of compression to such an extent that all condensate may be accumulated in adequate tankage before the gas is transported across the city to the plants where it is to be processed for the recovery of the gasoline contained in it. A pressure of approximately 50 lb. gauge is used to force the gas from the "Mansion Pool" to the older field south of the city, and is found to be adequate for transmission losses and to extract the available gasoline without again recompressing before it passes through the absorbers.

Water is produced at this plant for cooling engines and gas, and the excess pumped to the field to the north and west for drilling purposes. About 16,000 bbl. daily are produced from three drilled wells, which are flowed by air pressure. Air for this purpose is compressed in a unit in the compressor building and distributed to the three wells through adequate piping. Water pumped to the drilling wells is handled by a multi-stage centrifugal pump operated by a two-cylinder horizontal gas engine. Standard V-belts are used for power transmission in this unit, the driven pulley on the pump of which is grooved, but the flywheel of the engine is not grooved, the V-belts being run on the flat face of the flywheel.

Scrubbing of the gas is carried out in three vertical units (placed just inside the plant yard) through which all the gas passes before it enters the suction headers leading to the compressors. Provisions have been made in the design of these scrubbers to eliminate all liquid from the gas and to remove it automatically from them so that the operators are required only to supervise the operation of the automatic equipment.

The well organized construction department was shown at its best while constructing this compressor station. Approximately 60 days after construction of the station was authorized, 15 of the compressors had been set and placed in operation. The auxiliary equipment had been arranged for, the water wells drilled and equipped, lines laid and 13 engines in the second unit placed upon the concrete foundations. Buildings were erected, concrete floors laid, and the plant operating to the capacity of the engines already installed.

Approximately 300,000,000 cu. ft. of gas can be handled through the compressor station in the Mansion district and through the pressure gas line laid through Lincoln Terrace, engineers state, but if all the wells now drilling in that very active area are brought in as producers as large as those already completed, the problem may become a complicated one.

Welders completing last phase of construction on Phillips pipe line through Oklahoma City by welding in connections for fuel and wet gas service

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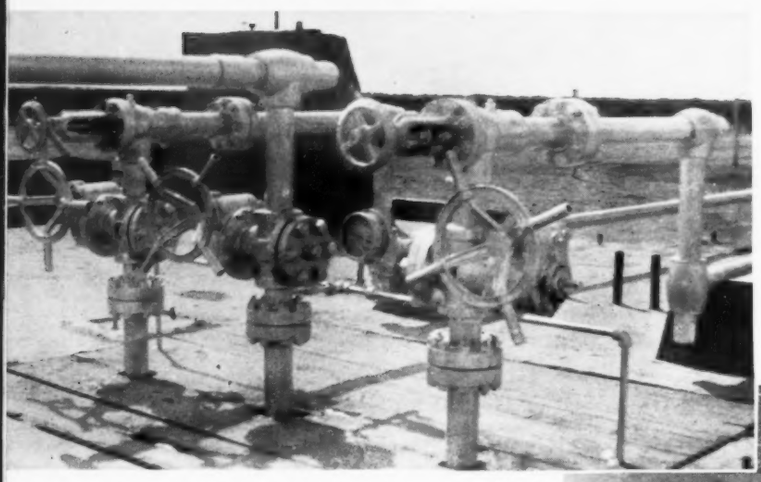

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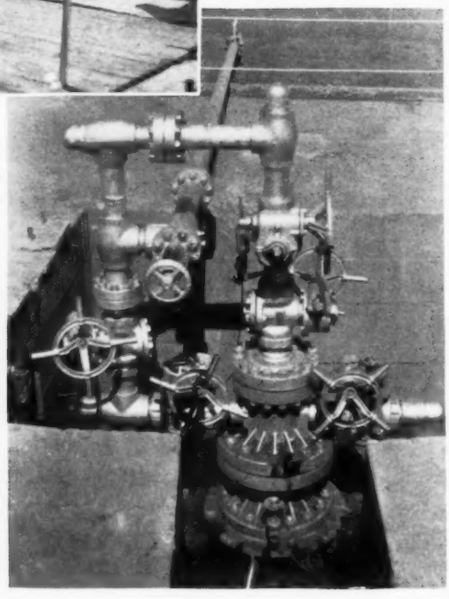

Top photo shows Nordstrom Hypreseal Valves on gas well Christmas tree at Button Willow, Calif. Center photo shows Hypreseals on Christmas tree in the Semi Tropic field, Calif. Lower photo shows type of Christmas tree developed by Nordstrom engineers, widely used in Texas and Oklahoma fields. Embodies round opening valve on tubing head and Hypreseals on flow lines.

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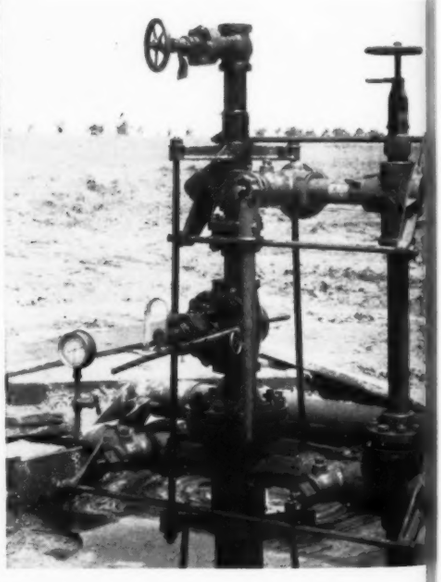

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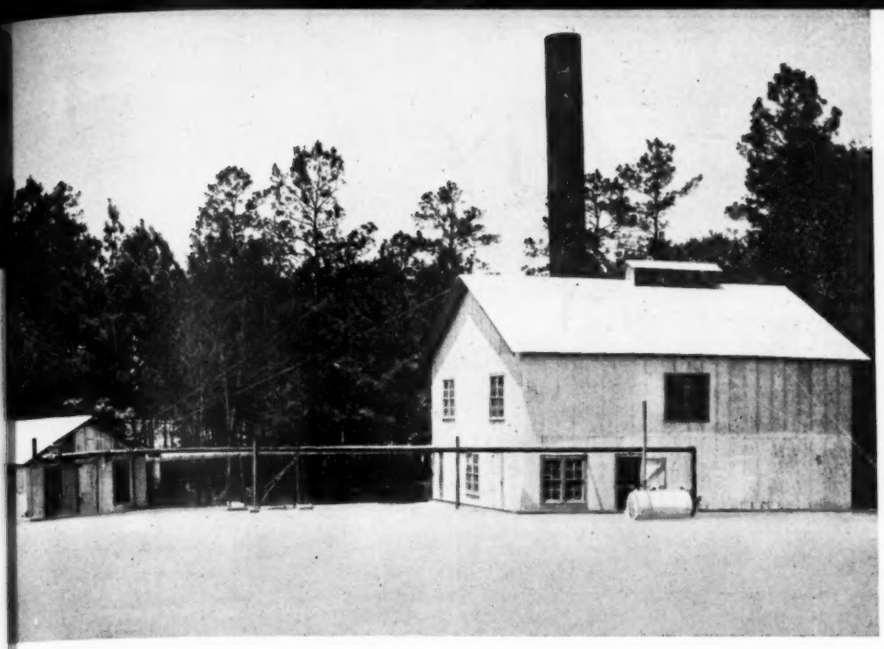


General view of East Texas Pipe Line Company's Sexton Station in Rodessa field proper

Low-Cost Fuel and Plentiful Supply of Good Water Led to Selection of Early Type of Equipment

Steam Turbines Provide Power for New Pipe Line Stations

By FRANK H. LOVE

IN deciding upon the type of pumping stations to install on its new 8-in. pipe line, recently completed between the Rodessa field of Louisiana and East Texas, the East Texas Pipe Line Company was motivated by two considerations: inexpensive gas and a plentiful supply of the proper kind of water. As a result the pumping equipment consists of centrifugal pumps driven by steam turbines. Equipment of this type for pipe line stations by no means is new; rather, it is one of the earliest to be employed. Its unusualness, however, lies in the fact that but few pipe line stations constructed within years have utilized steam turbines for driving pumps.

As is well known, gas is plentiful at Rodessa. That area was an extensive gas field many years prior to the discovery of oil there. The water, obtained from wells, is extremely soft, requires no treating, and is easily acquired. One well at each station drilled to a depth of 330 ft. suffices to meet all requirements.

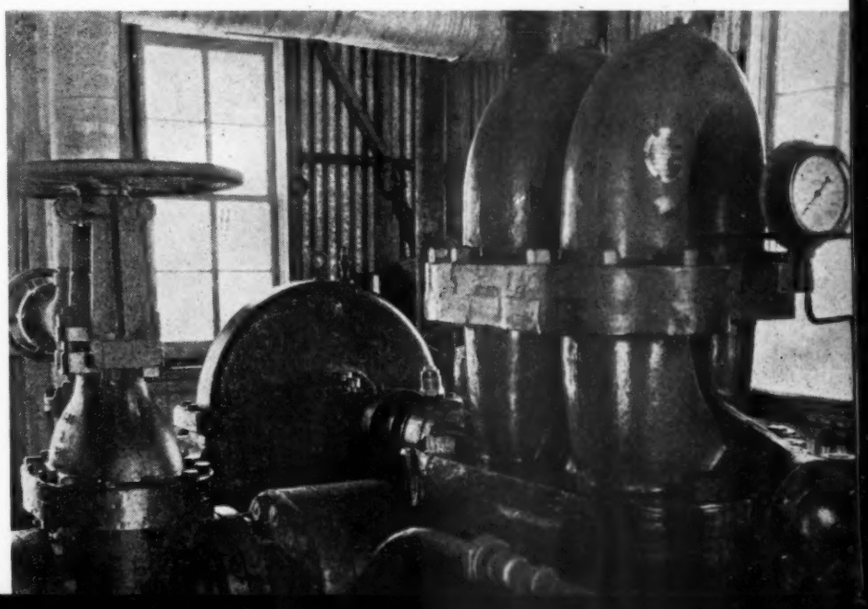
Two pumping stations have been erected, one in the Rodessa field proper, known as the Sexton Station, the other at Jefferson, Texas. They are identical in appointment except that the Sexton Station has working tanks while that at Jefferson has not.

Pumping equipment consists of two steam-driven turbines direct-connected to centrifugal pumps. The turbines, arranged in series, are rated each at 300 hp. and develop 3550 revolutions per minute. The individual pumping units have an operating pressure of 450 lb., and when compounded develop a pressure of 900 pounds.

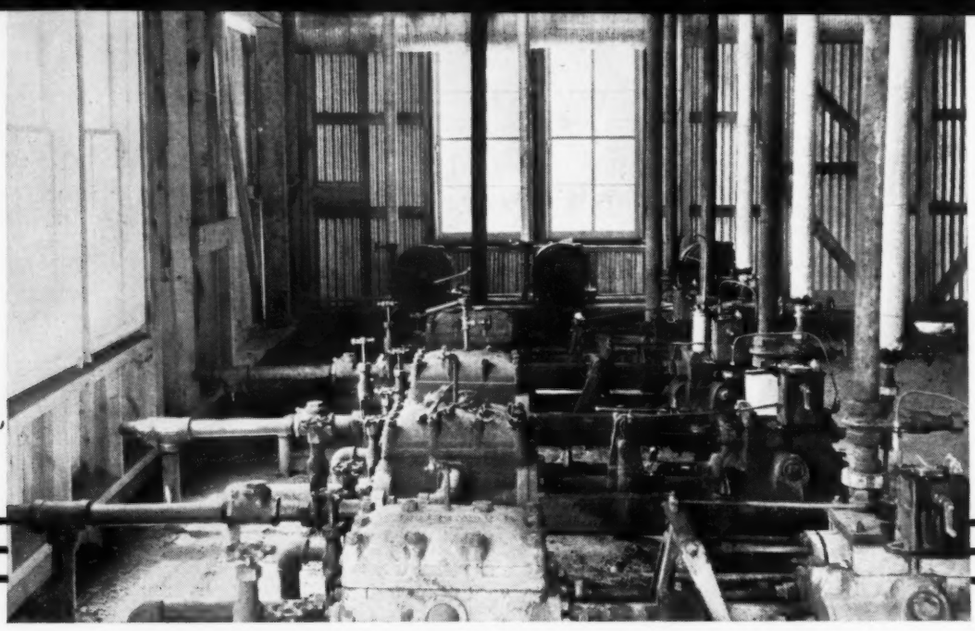
At either end of the units is a special bearing operating in an oilbath. The bearing is enclosed in a jacket, on the outside of which water is circulated to serve as a cooling medium for the oil. The latter is obtained from the suction line from the working tanks and prior to use is passed through a lubricator equipped with a screen for removing all foreign matter. The waste oil and water are piped to a 10-ft. by 12-ft. by 5-ft. concrete trap situated approximately 100 yards from the station building. The water is bled off and the oil picked up by the suction side of the lease pumps and boosted back into the working tanks.

The working tanks are of 55,000-bbl. capacity, and into these the crude is boosted from the lease tanks, gravitating to the suction side of the pumps, and thence discharged directly into the line.

The steam plant, providing power for the pumping units, is housed in a structure of galvanized iron covering measuring 36 ft. by 41 ft. with 20-ft. sidewalls. Steam equipment consists of three 250-hp. boilers, one of which is used as a standby. Water is fed to the boilers by 7 by 3 by 10 reciprocating pumps. There are four of these, two being standbys.



Centrifugal pumps driven by steam turbines



In the foreground are seen the boiler feed pumps. In background, against wall, are the generators. All are operated by steam

The pumps are housed in the same building as the boilers. Boiler water is obtained from a 330-ft. well situated near the building. Gas injected into the well serves to lift the water and boost it to a 1600-bbl. wooden tank, whence it gravitates to a hot water heater and thence to the boiler feed pumps. Provisions have been made for by-passing the water heater in event it is preferable to pick up cold water.

Steam and exhaust lines are of various sizes. The steam header is 28 in. in diameter. Off this header is an 8-in. steam line to the turbines. A 4-in. line branches from the 8-in. and supplies steam to the boiler feed pumps. It serves as a header and from it extend 1-in. lines to the individual pumps; also branching off the 8-in. steam line is a 2-in. to the generators, the latter being four in number and employed to provide the electricity needed for lighting purposes. The main steam line is insulated and wrapped with tin to retard condensation. As a means of insuring a minimum volume of condensation reaching the turbines a 12-in. baffle has been installed immediately outside the pump house. Exhaust from the pumping units is utilized by the hot water heater, being carried to that equipment by a 6-in. line.

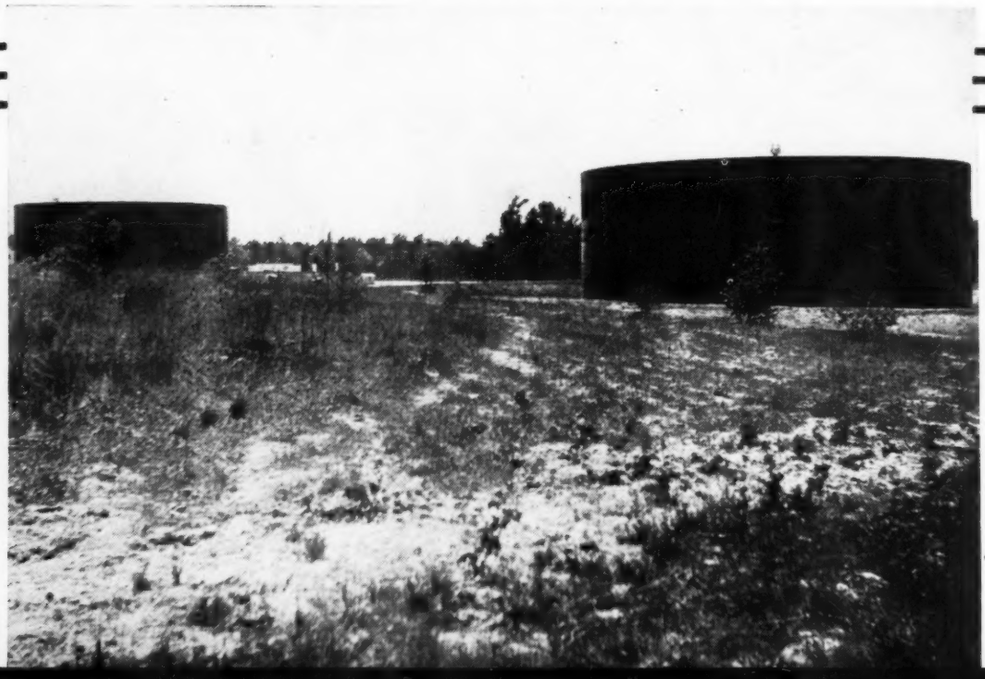
Residue gas is used as fuel at the boilers and is obtained from a 10,000,000 cu. ft. capacity natural gasoline plant recently erected in the Rodessa field by the same interests that own the pipe line.

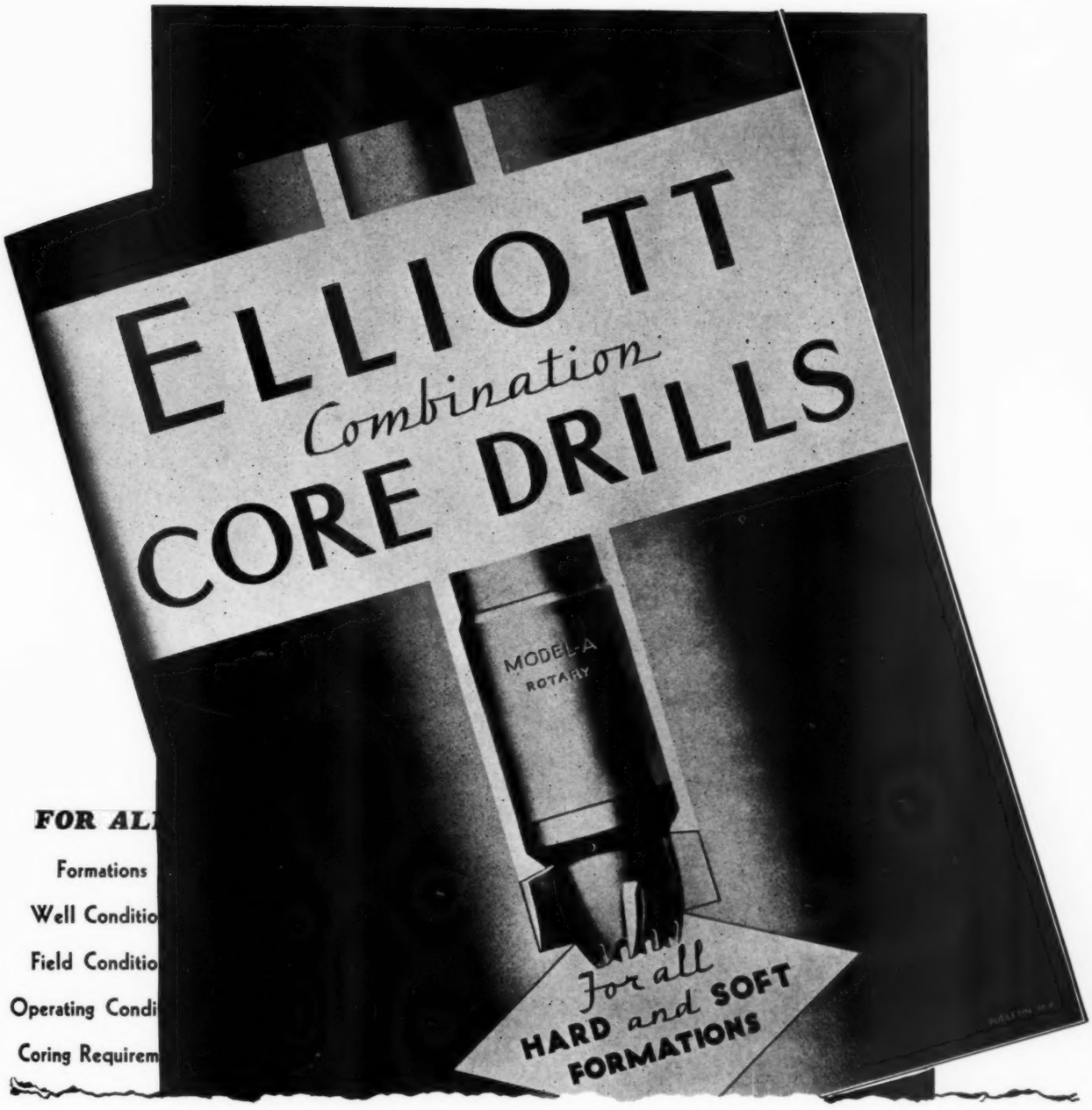
Gathering lines are 4 in. and 6 in. in size, and carry crude from 13 wells on the Louisiana side of the field and from one in Cass County across the line into Texas, oil from the latter well going directly to the station at Jefferson. Gathering equipment consists of reciprocating steam pumps of various sizes, some being 7 by 6 by 10, others 10 by 6 by 10, and still others 7 by 3½ by 10.

All buildings have a wooden framework covered with galvanized corrugated iron. The pumping equipment is housed in a structure 16 ft. by 18 ft. with 10 ft. sidewalls, and, as previously mentioned, the building containing the boilers, boiler feed pumps, and generators, is 36 ft. by 41 ft. with 20-ft. sidewalls.

The rated capacity of the stations is 30,000 bbl. of crude per day, although less than that quantity is being moved at the present time.

Two 55,000-bbl. working tanks are employed at Sexton Station





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A Bureau of Mines Study of a "Bottom Hole" Sample from the Crescent Pool, Oklahoma

with Regard to Liberation of Gas, Expansion of the Oil-Gas Mixture and Energy Relations Involved in Flow[1]

By BEN E. LINDSLY[2]

Part 5 (Concluding)

Estimated PV Curve for Reservoir Fluid Under Flowing Conditions

Isothermal curves do not represent correctly the volumetric changes that an oil-gas mixture undergoes in its movement through the sand to the bottom of the well and thence to the surface. When a well is flowing there may be a considerable change of temperature along the path traveled by the fluid, depending upon the rate of flow, the expansibility and other properties of the flowing medium, and the reduction in pressure.

If a number of isothermal expansions of the bottom-hole oil had been made at intervals of temperature from 149° to 70° F., a series of curves lying between *G* and *H*, fig. 13, could be drawn to represent the isothermal pressure-volume relations of the reservoir fluid at the various intermediate temperatures. Then if a pressure-temperature traverse of the well during flow were available a curve could be drawn extending from the flowing bottom-hole pressure to the wellhead pressure that would represent closely the pressure-volume relations of the fluid in its movement from the bottom to the top of the well. Such a curve also could be extended upward to the reservoir pressure to represent the pressure-volume relations of the fluid in its flow through the sand, although the selection of the path of the extension must be more or less arbitrary because of lack of knowledge of the pressure-temperature relations in the formation. The curve then would start at the upper end of *G*, pass downward and to the right between *G* and *H*, crossing the various isothermal curves at the appropriate pressure values, and intersect the horizontal line representing the wellhead pressure.

If the fluid expanded and did work beyond the wellhead (for example, if it continued its upward flow in a pipe rising from the wellhead) with its temperature falling gradually to a value of 70° F. at 14.4 lb./in.² abs., the pressure-volume relations of the fluid would be represented by a downward extension of the curve above mentioned, ending at the lowest point of curve H.

Although the Bureau of Mines has developed instruments for making pressure-temperature traverses of wells and is conducting studies of that character, other work prevented taking pressure-temperature data in the Crescent pool well. Moreover, conditions under which the tests herein reported were made prevented expansion of the bottom-hole sample at more than two temperatures. Therefore, for purpose of illustration and not purporting to represent the conditions exactly curve *K*, fig. 13, has been estimated to represent the pressure-volume relations of 1 cu. ft. of reservoir fluid (measured at 2829 lb./in.² abs and 149° F.) during its flow from the formation to the wellhead. Also the curve has been extended (curve *L*, fig. 13) to represent pressure-volume relations that might obtain if the fluid were allowed to do work beyond the wellhead, with its temperature falling gradually to 70° F. Although the path of curve *KL* is chosen arbitrarily section *K* probably is more nearly representative of relations below the wellhead than either of the isothermal curves, and section *L* gives what seems to be a more reasonable basis than the isothermal curves for estimating the capacity of the fluid at the wellhead to do further work.

Indicated Work of Bottom-Hole Oil and Reservoir Fluid Compared with Work Required to Lift Fluid to Wellhead

Table 8 shows the indicated work of the bottom-hole oil and reservoir fluid over the pressure ranges and under the temperature conditions specified in the table. It will be noted that neither fluid could lift itself 6100 ft. expanding isothermally at 70° F. between the pressures of 2575 and 894 lb./in.² abs. but that the total indicated work between 2829 and 14.4 lb./in.² abs. (at 70° F.) is equivalent to a lift of about 22,000 ft. for the bottom-hole oil and about 24,000 ft. for the reservoir fluid.

If the efficiency of flow in the well is taken as

$$\frac{100 \times \text{work of lifting unit of fluid 6100 ft.}}{\text{indicated work of unit of fluid between 2575 and 894 lb./in.}^2 \text{ abs.}}$$

flowing efficiencies of about 90 and 85 percent would be required to lift the bottom-hole oil and reservoir fluid, respectively, under isothermal conditions at 149° F. On the other hand, the overall efficiencies, if defined as

$$\frac{100 \times \text{work of lifting unit of fluid 6100 ft.}}{\text{indicated work of unit of fluid between 2829 and 14.4 lb./in.}^2 \text{ abs.}}$$

would be only about 19 and 18 percent, respectively. For the assumed path of expansion *KL* the efficiency in the flow string is 90.3 percent and the overall efficiency 22.5 percent (by graphic integration).

Relative Importance of Work Due to Change in Pressure Head and Work Due to Expansion

Reference has been made to the relative importance of the work due to change in pressure head and the work due to expansion over the various pressure ranges. This is shown graphically in fig. 16, where cumulative values of the work

are plotted. Curves *A*, *B*, and *C* show the values at the various pressures, P_2, of 144 $(P_1V_1 - P_2V_2)$, $144\int_{V_1}^{V_2} PdV$, and 144 $(P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV)$, respectively, for 1 cu. ft. (45.8 lb.) of bottom-hole oil expanding isothermally at 149° F. from an initial pressure $P_1 = 2829$ lb./in.² abs. It will be noted that 144 $(P_1V_1 - P_2V_2)$ increases to a maximum and then decreases (column 6, table 7); also that $144\int_{V_1}^{V_2} PdV$ is relatively small at the higher pressures but is the major term at the lower pressures (column 7, table 7).

For comparison with curve *C* (plotted from column 10, table 7), curve *D* shows the indicated work $144\ (P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV) = 144 \left\{ V\ (P_1 - P_2) + 0 \right\}$ of 1 cu. ft. of a hypothetical incompressible, nonvolatile liquid, and curve *E* shows $144\ (P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV) = 144\ (0 + \int_{V_1}^{V_2} 2829\ V^{-1}dV) = 144 \times 2829 \log_e \frac{V_2}{V_1}$ for 1 cu. ft. (measured at 2829 lb./in.² abs.) of an ideal gas expanding isothermally, through the same pressure ranges. The predominating influence of the liquid at the higher pressures and of the liberated gas at the lower pressures is clearly discernible in the shape of curve *C*. Curves *A'*, *B'*, and *C'*, fig. 16, correspond to curves *A*, *B*, and *C* but represent the work values for 1 cu. ft. of reservoir fluid (45.2 lb.) expanding with the temperature falling from 149° F. at 2829 lb./in.² abs. to 70° F. at 14.4 lb./in.² abs. (based on curve *KL*, fig. 13). It will be noted that in this case 144 $(P_1V_1 - P_2V_2)$ continues to increase as P_2 decreases.

FLOW IN TERMS OF HORSEPOWER

Since 1 bbl. of reservoir fluid measured at 2829 lb./in.² abs. and 149° F. yields about 0.755 bbl. of residual oil measured under atmospheric conditions (Appendix B), the 18 bbl. of residual oil per hour that was flowing before the well was shut in for sampling is equivalent to about $\frac{18}{0.755} = 23.8$ bbl. per hour, or $\frac{23.8 \times 5.615}{60} = 2.23$ cu. ft./minute, of initial oil measured under reservoir conditions. If the reservoir fluid weighs 45.2 lb./cu. ft., lifting it at this rate through a height of 6100 ft. is equivalent to $\frac{2.23 \times 45.2 \times 6100}{33{,}000} = 18.6$ horsepower. The "indicated horsepower" of the fluid at the flow-rate of 2.23 cu. ft. of initial fluid per minute may be obtained by multiplying the indicated work (see table 8) by $\frac{2.23}{33{,}000}$. Based on curve KL, fig. 13, and graphic integration, the results are:

2.5 horsepower between 2829 and 2575 lb./in.² abs.
20.6 horsepower between 2575 and 894 lb./in.² abs.
59.6 horsepower between 894 and 14.4 lb./in.² abs.

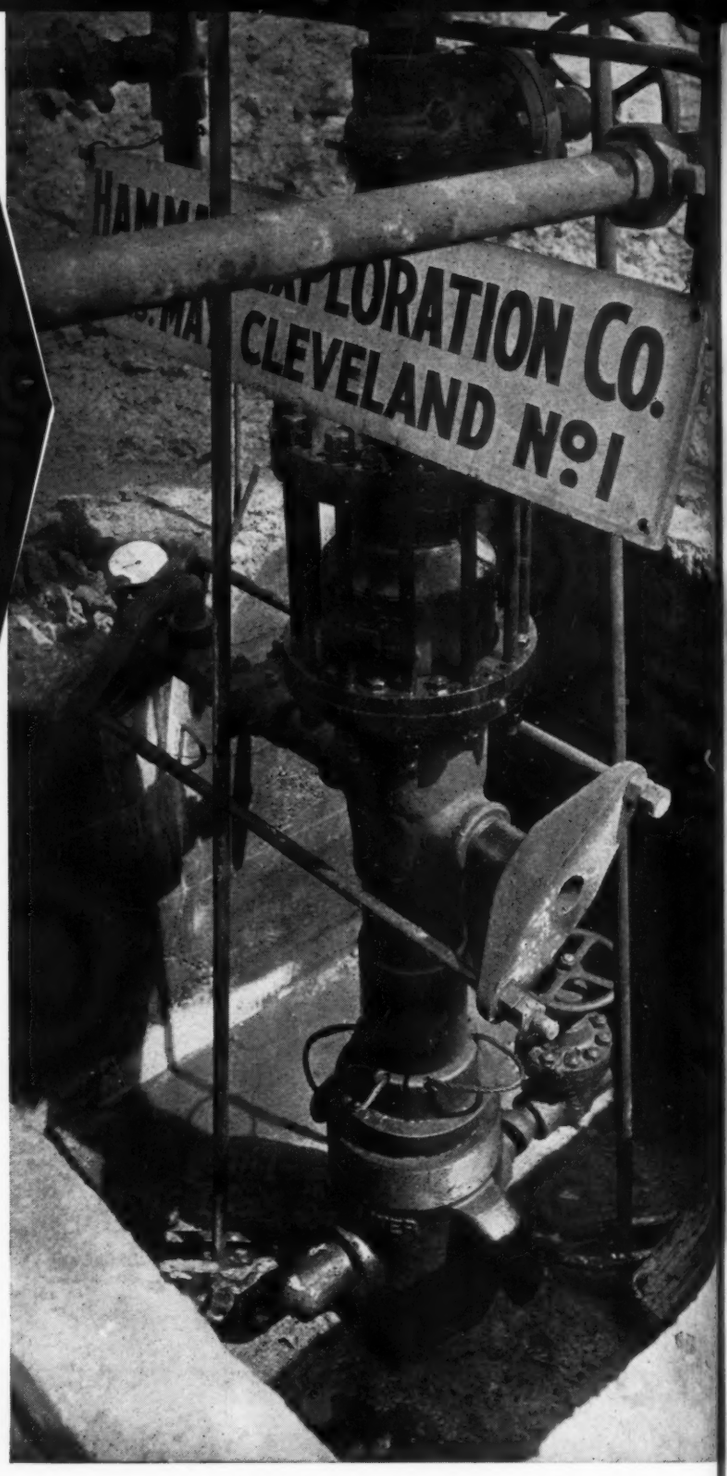
82.7 horsepower between 2829 and 14.4 lb./in.² abs.

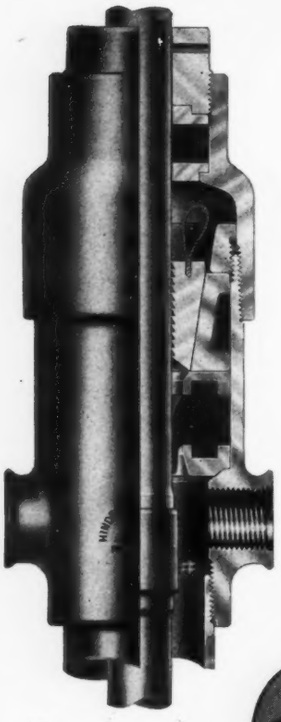
Table 8.—Indicated Work of Bottom-Hole Oil and Reservoir Fluid Compared with Work Required to Lift Fluid to Well Head.

Unit of fluid	Weight of unit of fluid, lb.	Curve showing pressure-volume relations in expansion with flash liberation	Temperature relations during expansion	Indicated work of unit of fluid, ft.-lb.				Work of lifting unit of fluid 6100 ft.		
				From 2829 to 2575 lb./in.² (in reservoir)	From 2575 to 894 lb./in.² (in flow string)	From 894 to 14.4 lb./in.² (beyond wellhead)	From 2829 to 14.4 lb./in.² (total)	Ft-lb.	Percent of indicated work of fluid in flow string	Percent of total indicated work of fluid
1 cu. ft. of *bottom-hole* oil, measured at 2829 lb./in.² and 149° F.	45.8	A, fig. 12, and $A_1A_2A_3$, fig. 13	Isothermal at 149° F.	36,630 [a]	310,700 [a]	1,109,500 [a]	1,456,800 [a]	279,400 [c]	89.9 [a]	19.2 [a]
				36,600 [b]	310,400 [b]	1,097,800 [b]	1,444,800 [b]		90.0 [b]	19.3 [b]
1 cu. ft. of *bottom-hole* oil, measured at 2829 lb./in.² and 70° F., equivalent to 1.043.8 cu. ft. measured at 2829 lb./in.² and 149° F.	47.8	B, fig. 12, and $B_1B_2B_3$, fig. 13	Isothermal at 70° F.	36,600 [a]	273,100 [a]	760,000 [a]	1,069,700 [a]	291,600 [c]	106.8 [a]	27.3 [a]
				36,600 [b]	272,400 [b]	750,300 [b]	1,059,300 [b]		107.1 [b]	27.5 [b]
1 cu. ft. of *reservoir* fluid, measured at 2829 lb./in.² and 149° F.	45.2	G, fig. 13	Isothermal at 149° F.	37,200 [a]	324,700 [a]	1,172,900 [a]	1,534,800 [a]	275,700 [c]	84.9 [a]	18.0 [a]
				37,100 [b]	324,300 [b]	1,159,000 [b]	1,520,400 [b]		85.0 [b]	18.1 [b]
0.957 cu. ft. of *reservoir* fluid, measured at 2829 lb./in.² and 70° F., equivalent to 1 cu. ft. measured at 2829 lb./in.² and 149° F.	45.2	H, fig. 13	Isothermal at 70° F.	35,300 [a]	271,300 [a]	790,500 [a]	1,097,100 [a]	275,700 [c]	101.6 [a]	25.1 [a]
				35,200 [b]	270,100 [b]	774,800 [b]	1,080,100 [b]		102.1 [b]	25.5 [b]
1 cu. ft. of *reservoir* fluid, measured at 2829 lb./in.² and 149° F.	45.2	KL, fig. 13	Temperature falling from 149° F. at 2829 lb./in.² to 70° F. at 14.4 lb./in.²	37,000 [a]	305,300 [a]	882,300 [a]	1,224,600 [a]	275,700 [c]	90.3 [a]	22.5 [a]
				.....	.....	.....	.....	.....	.....	.....

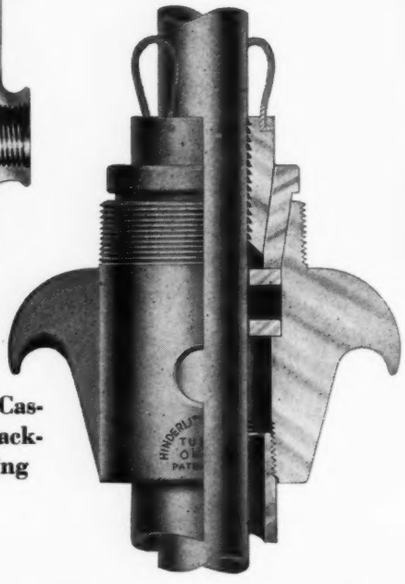
[a] By graphic integration.
[b] By mathematical integration.
[c] 6100 X weight of unit of fluid.
Note: All pressures are absolute.

Deepest Controlled by





HZ—Three-In-One Casing Head Hook-Up with Top Packing Gland.



HJ—Bushing Type Casing Support and Packing Head with Lifting Ears.

This well drilled by the Hamman Exploration Co. near Bay City, Matagorda County, Texas, is producing from 9,439 feet. 8,300 feet of 7 inch 26 lb. casing. Casing pressure 2,950 lbs. Tubing pressure 1,900 lbs.

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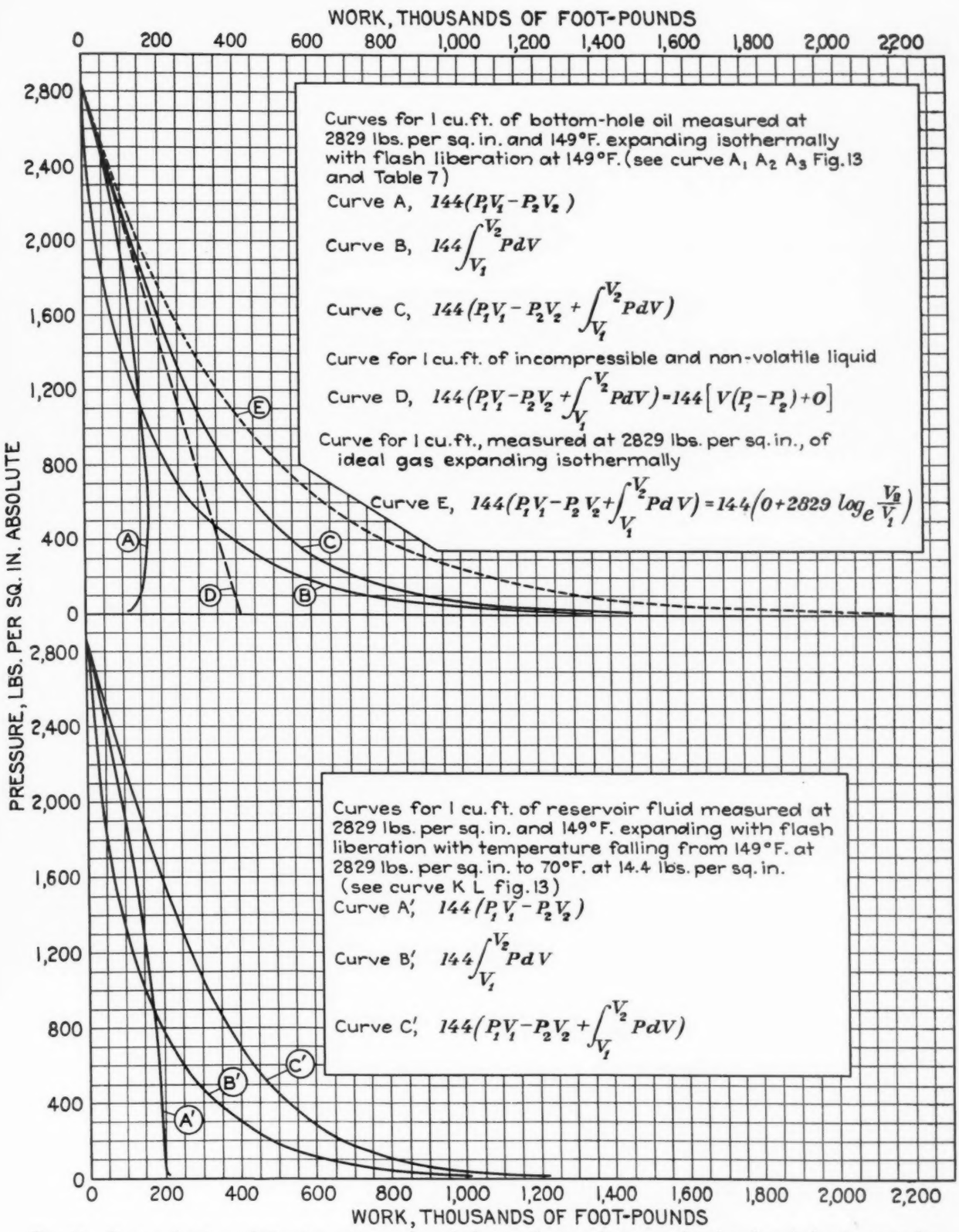
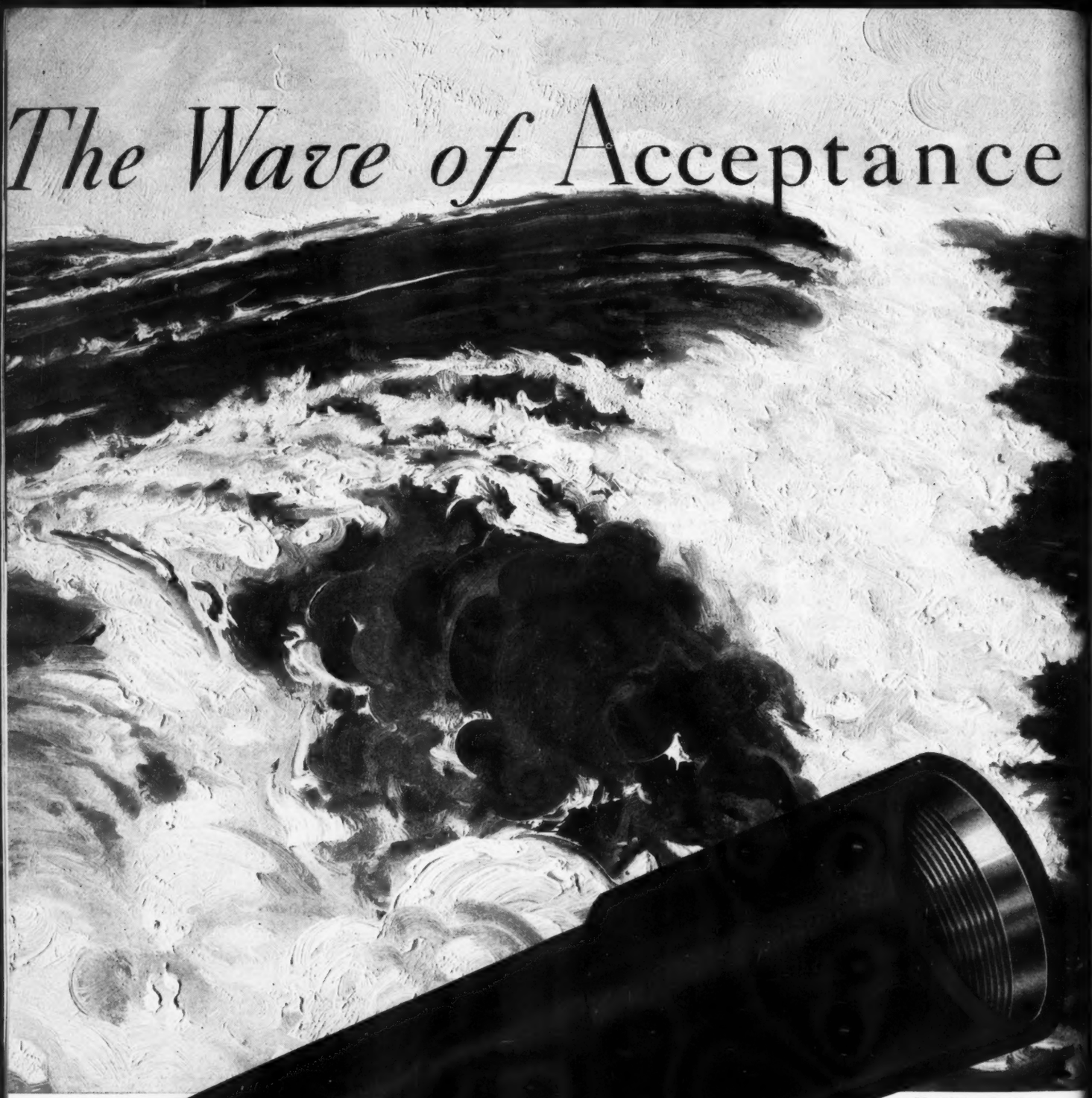

WORK, THOUSANDS OF FOOT-POUNDS
0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000 2,200
PRESSURE, LBS. PER SQ. IN. ABSOLUTE
2,800 2,400 2,000 1,600 1,200 800 400 0
Curves for 1 cu.ft. of bottom-hole oil measured at 2829 lbs. per sq. in. and 149°F. expanding isothermally with flash liberation at 149°F. (see curve A1 A2 A3 Fig. 13 and Table 7)
Curve A, $144(P_1V_1 - P_2V_2)$
Curve B, $144\int_{V_1}^{V_2} PdV$
Curve C, $144\left(P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV\right)$
Curve for 1 cu.ft. of incompressible and non-volatile liquid
Curve D, $144\left(P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV\right) = 144\left[V(P_1 - P_2) + 0\right]$
Curve for 1 cu.ft., measured at 2829 lbs. per sq. in., of ideal gas expanding isothermally
Curve E, $144\left(P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV\right) = 144\left(0 + 2829 \log_e \frac{V_2}{V_1}\right)$
A B C D E
Curves for 1 cu. ft. of reservoir fluid measured at 2829 lbs. per sq. in. and 149°F. expanding with flash liberation with temperature falling from 149°F. at 2829 lbs. per sq. in. to 70°F. at 14.4 lbs. per sq. in. (see curve K L fig. 13)
Curve A′, $144(P_1V_1 - P_2V_2)$
Curve B′, $144\int_{V_1}^{V_2} PdV$
Curve C′, $144\left(P_1V_1 - P_2V_2 + \int_{V_1}^{V_2} PdV\right)$
A′ B′ C′
0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000 2,200
WORK, THOUSANDS OF FOOT-POUNDS

Fig. 16. Curves showing relative importance of work due to change of pressure head and work due to expansion

DISCUSSION OF RESULTS

The indicated efficiency of about 90 percent ($\frac{18.6}{20.6} \times 100$) for the flow from the bottom of the well to the wellhead may raise questions as to whether some of the estimates and assumptions on which it is based may not be in error. The saturation pressure of the bottom-hole oil at the time Sidwell and Collins[5] made their pressure traverse is not definitely

The Wave of Acceptance



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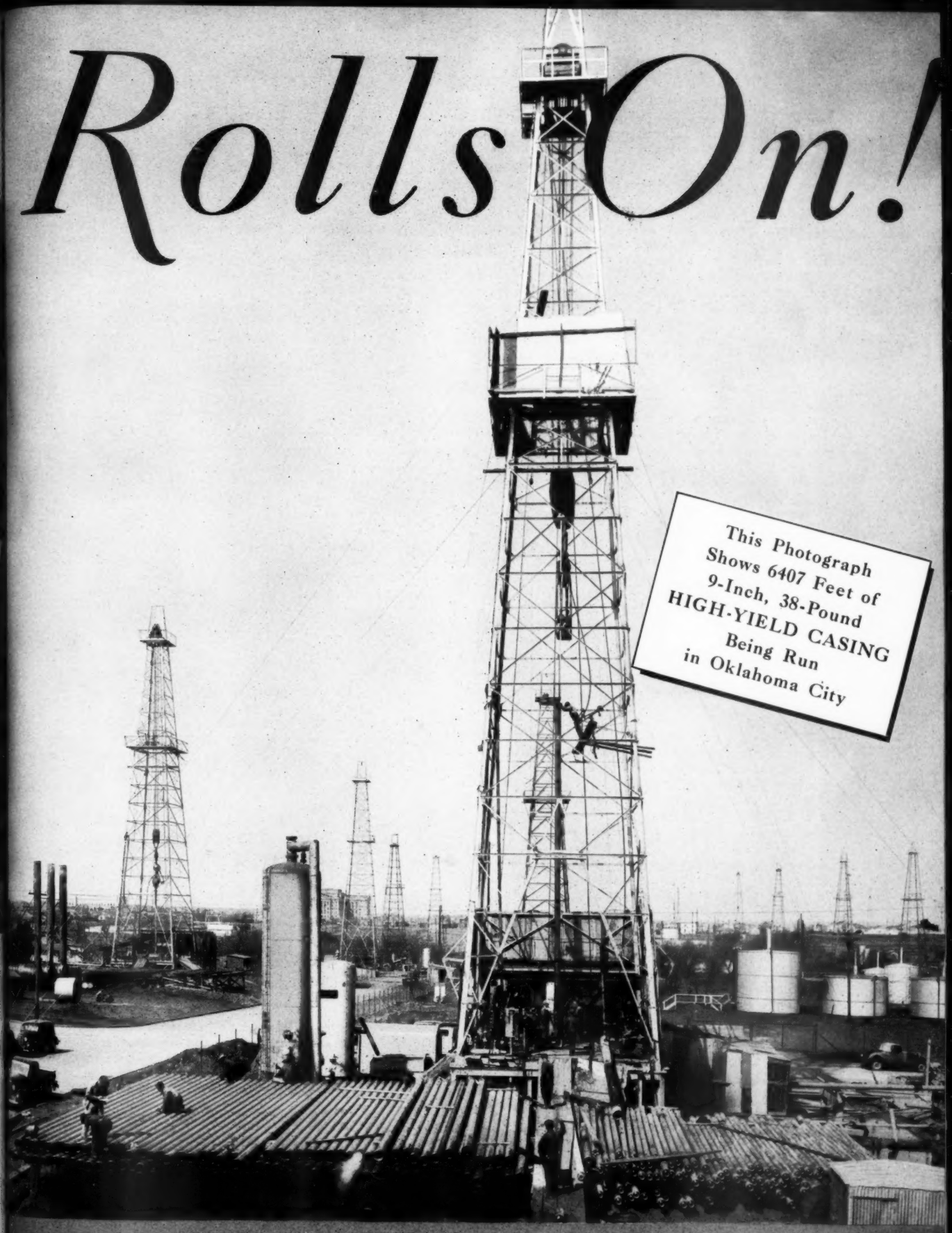

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known; and it seems possible, particularly in view of the gravity of the bottom-hole oil determined by Katz[6] from his analysis that the oil was somewhat lighter than has been estimated. Also it is possible that the bottom-hole pressure during flow was a little higher than 2575 lb./in.^{2} abs., that some gas evolved from oil that remained in the reservoir accompanied the oil flowing from the well, and that curve *K*, fig. 13, should lie nearer curve G. Regardless, however, of errors that may be involved it seems evident that the efficiency of flow in the well was of the order of 80 to 90 percent.

This high efficiency undoubtedly was due to low velocity and small volumetric increase of the flowing mixture. At the wellhead pressure (894 lb./in.^{2} abs.) the volume of the fluid mixture was less than twice its volume under reservoir conditions. With a flow of 2.23 cu. ft. of reservoir fluid per minute the volumetric rate of flow at the wellhead (based on curve KL, fig. 13) was about $1.83 \times 2.23 = 4.08$ cu. ft. per minute. Since the cross-sectional area of the flow string was approximately 0.24 sq. ft. the velocity of the flowing mixture at the wellhead was about 17 ft. per minute or 0.28 ft. per sec. Such a condition was ideal for efficient flow. The low velocity minimized friction, and with the small increase in volume the mixture probably was a true foam consisting at the wellhead of about equal parts of liquid and of gas in the form of minute bubbles, so "slippage" also was small.

With a higher rate of flow the bottom-hole and wellhead pressures would be lowered, the indicated work of the fluid in the formation and in the well would be increased, and the capacity of the fluid for doing work beyond the wellhead would be decreased. A change in flowing conditions might alter the path of the pressure-volume curve (such as KL, fig. 13) but probably would make no large change in the total indicated work of the fluid between reservoir and atmospheric pressures. Therefore, although with a higher rate of flow the efficiency in the well might be much less than 90 percent, the overall efficiency (as defined on p. 113) probably still would be of the order of 20 to 25 percent.

CONCLUSION

This paper, based on results from only one bottom-hole sample, is intended to illustrate ways in which reservoir data may be obtained, analyzed, and used rather than to depict the exact conditions in the well from which the sample was taken. If the report suggests equipment and methods that will aid others who desire to make similar studies, it will have served its primary purpose. Much additional study along the lines herein suggested, together with studies of thermal properties of natural hydrocarbon mixtures, is needed to aid the industry to understand the flow of oil in formations and in wells and to foster more efficient use of the energy associated with the fluids.

The most striking data in this paper are:

(1) The shrinkage, under the various conditions described, of 19 to 38 percent in the volume of the oil with reduction of pressure and liberation of gas.

(2) The capacity of the reservoir fluid to do 4 or 5 times the work that is represented by the lifting of the fluid from the reservoir to the surface.

(3) The high indicated efficiency (of the order of 90 percent) of the flow in the well.

(4) The large capacity of the fluid at the wellhead to do additional work.

It would be desirable, if practicable, to limit the quantity of gas produced with the oil so that the mechanical energy associated with the fluid would not exceed the amount required to raise it to the surface; thus a maximum of energy would remain available to raise oil in the future. However, when the gas produced with the oil results from liberation of lighter hydrocarbons that entered the bottom of the well as part of the liquid, reduction of the quantity of gas produced is difficult, if not impossible. In other words, it would seem impossible to produce a barrel of oil with less gas than was dissolved in it in the reservoir.

With a higher rate of flow from the well the capacity of the wellhead fluid for doing work might be only a fraction of the 883,000 ft-lb. per cu. ft., or nearly 5,000,000 ft-lb. per bbl., indicated by curve KL, fig. 13, and recorded in table 8; however, the work this fluid could do is likely to be considerable under any system of regulated production. Sometimes use is made of the mechanical energy of the wellhead fluid, as, for example, when the gas is delivered into a high-pressure pipe line. More often, however, the fluid is throttled from the wellhead, thus transforming energy from an available to an unavailable form. Whether it is practicable to make use of the available energy from the wellhead fluid depends upon physical and economic factors pertaining to the individual case.

During the past few years the desirability of maintaining pressure in oil pools by returning excess gas to the sand has been demonstrated at Sugarland and Raccoon Bend, Tex., and elsewhere. Determination of the proper time to return gas to the producing formation involves questions of both technology and economics. In the early life of many oil pools gas that could do a great deal of mechanical work is blown to the air, and if the time of returning gas is delayed until the wells are on the verge of ceasing to flow the flowing efficiencies in the wells may be low because of high velocities and of gas-liquid ratios that give unfavorable conditions for formation of satisfactory foams and thus produce large slippage effects. Furthermore, in the later life of a field the gas available for return to the sand is likely to be at low pressure, requiring a high ratio of compression to force it into the input wells.

If the operator delays the time of returning excess gas to the sands he may be confronted with two adverse conditions: (1) Excessive gas-oil ratios, resulting in high flow-string velocities, slippage, friction, flow by heads, and generally inefficient flowing processes; and (2) a repressuring medium containing but a small percentage of the energy associated with the gas produced in the earlier period, requiring compression through a high ratio before it can be used effectively for driving oil through the sand to the well and raising it from the bottom of the well to the lease tanks on the surface. At an earlier period conditions generally are more suitable for efficient flow, and it may be necessary to add only a comparatively small amount of energy to the large amount already available from the high-pressure gas to maintain efficient flow.

Analyses of the kind discussed in this paper will be helpful in determining the economics involved in making capital investments for engines and compressors to return gas to the sand for maintaining reservoir pressure early in the life of an oil field compared with delaying investments for such machinery until later. It would seem that in many instances an early capital investment would be smaller than a later one, which would involve installation of compressors to handle low-pressure gas; also, the overall operating and lifting costs probably would be less because of more efficient flowing conditions and lower compression ratios. The writer believes that maintaining pressure early in the life of a field generally will be more favorable than repressuring later and that the benefits to be derived from such practice will result not only in reducing the overall lifting costs but also will yield a greater ultimate recovery of oil. Viewed in a broad sense the efficient utilization of reservoir energy is a problem directly connected with the conservation of the Nation's petroleum resources and therefore is of vital concern not only to oil producers but to the consuming public.

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"This method is applicable to wells where your impervious formation is very narrow, or where your producing sands are cranky.

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"Figure 14, here in the book, shows you the commonly used way to test the efficiency and extent of ordinary cement jobs . . . whether squeeze or full-hole-cemented casings . . . by Gun-Perforating the shale either below or above the water stratum. In some cases, it's wise to test both above AND below, for a double check on your water shut-off."

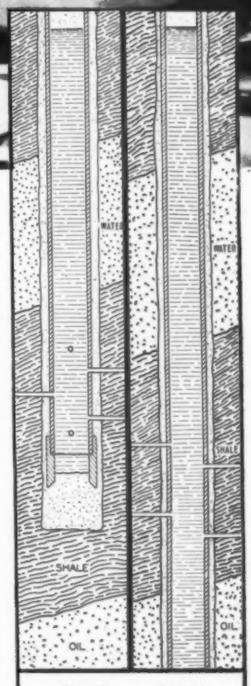

Fig. 13 Fig. 14

Fig. 13—Casing Shoe Test

Fig. 14—Intermediate Test

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APPENDIX A

Construction of Curves C, D, E, F, G, and H, Fig. 13

Curve $A_1A_2A_3$, fig. 13, shows the total volume (liquid plus gas) of a bottom-hole sample occupying a volume of 1 cu. ft. at 2829 lb./in.^{2} and 149° F. expanded isothermally at 149° F. with flash liberation. This sample is in the liquid phase from 2829 lb./in.^{2} abs. to the saturation pressure of 2575 lb./in.^{2} abs. and in two phases below that pressure. Because of the tendency for oil to cling to the walls of the expansion chambers the volume of the liquid phase cannot be determined directly from flash-liberation experiments of the kind used in this work. It is known that shrinkage of the oil in flash liberation is not identical with that in differential liberation; however, the difference in shrinkage is of considerable magnitude only at the lower pressures, where the oil volume is a very small percentage of the total volume of the mixture. A difference of several percent between the liquid volumes indicated by the low-pressure end of the 149° F. differential-liberation shrinkage curve and the actual liquid volumes in the flash-liberation test will be equivalent to only a small fraction of 1 percent of the gas volume. Therefore curve C, plotted by subtracting the liquid volumes indicated by the 149° F. curve of fig. 7 from the volumes of the flash-liberation sample at the corresponding pressures, as indicated by curve $A_1A_2A_3$, fig. 13, gives a close approximation of the pressure-volume relations of the gas phase of the 149° F. flash-liberation sample.

In a like manner, using curve $B_1B_2B_3$ (fig. 13) and the 70° F. shrinkage curve of fig. 7, curve D. (fig. 13) has been plotted to indicate the volume of the gas phase of the 70° F. flash-liberation sample. It is important to observe that the increasing volume of the gas phase with reduction in pressure, as indicated by curves C and D, primarily is the result of two effects: (1) The progressive transfer of hydrocarbons from the liquid to the gaseous phase, and (2) the expansion with reduction in pressure of the gas in the gaseous phase.

Identical samples of oil expanded from high to low pressure with flash and differential liberation will not evolve the same quantities of gas. However, these differences in gas liberated are of considerable magnitude only at the lower pressures. Over a relatively small pressure drop at the beginning of an expansion the quantity of gas evolved with flash liberation should be practically the same as that given off with differential liberation, and there should be little difference in the compositions of the gases liberated in the two instances.

According to the 149° F. curve (extrapolated) of fig. 7, starting with a sample consisting of 1.0234 cu. ft. of reservoir fluid saturated at 2829 lb./in.^{2} abs. and 149° F. and reducing the pressure to 2575 lb./in.^{2} abs. would give a liquid phase of the same composition as the sample of bottom-hole oil occupying a volume of 1.0025 cu. ft. at the latter pressure. According to curves A' and D', fig. 8, the corresponding gas phase would be 73 cu. ft. of gas (14.4 lb./in.^{2} abs. and 70° F. base) per bbl. of residual oil, or $\frac{73}{5.615} =$ 13.0 cu. ft. of gas per cu. ft. of residual oil.

Since the residual oil is 71.17 percent of the volume of the sample at 2829 lb./in.^{2} abs. this is equivalent to 13.0 × .7117 = 9.26 cu. ft. of gas (14.4 lb./in.^{2} abs. and 70° F. base) per cu. ft. of oil saturated at 2575 lb./in.^{2} and 149° F. and measured at 2829 lb./in.^{2} abs. and 149° F. (equivalent to the initial cubic feet of the 149° F. sample of bottom-hole oil). Reducing the pressure on the sample of reservoir fluid to 2321 lb./in.^{2} abs. (curves A' and D', fig. 8) would yield another 9.26 cu. ft. of gas (14.4 lb./in.^{2} abs. and 70° F. base). Each of these 9.26-cu. ft. increments of gas would have approximately the same composition, and on the basis of the first analysis of columns 6 to 11, table 2, would weigh about 0.42 lb. (0.0454 lb./cu. ft.). A volume of 9.26 cu. ft. of gas measured at 14.4 lb./in.^{2} abs. and 70° F. would occupy approximately $9.26 \times \frac{609}{530} =$ 10.64 cu. ft. at 14.4 lb./in.^{2} abs. and 149° F.

At the pressure of 2829 lb./in.^{2} abs. this 0.42 lb. of hydrocarbons (equivalent to 9.26 cu. ft. of gas at 14.4 lb./in.^{2} abs. and 70° F.) would occupy 0.0234 cu. ft. of liquid volume (extrapolated 149° F. curve of fig. 7). This is equivalent to a weight of 17.9 lb. per cu. ft. With a fall in pressure to 2575 lb./in.^{2} abs. these hydrocarbons would increase the volume of the sample of reservoir fluid by (1) a progressive change from liquid to gas and (2) expansion as a gas. At the pressure of 2575 lb./in.^{2} abs. all this 0.42 lb. of hydrocarbons would be in the gaseous phase and with further reduction in pressure would expand as a gas (but not following the laws of an ideal gas) to a volume of 10.64 cu. ft. at atmospheric pressure.

The volume occupied at the pressure of 2575 lb./in.^{2} abs. by this first 0.42 lb. of gas liberated from the sample of reservoir fluid (1.0234 cu. ft. of liquid at 2829 lb./in.^{2} abs. and 149° F.) cannot be determined directly but it may be estimated closely by considering the first 0.42 lb. of gas liberated from the bottom-hole sample (1.0000 cu. ft. of bottom-hole liquid measured at 2829 lb./in.^{2} abs. and 149° F.). This first 0.42 lb. of gas, evolved from the bottom-hole sample between the pressures of 2575 and 2321 lb./in.^{2} abs., corresponding to the second 0.42 lb. of gas that would be liberated from the sample of reservoir fluid, would make up the entire gas phase of the bottom-hole sample at 2321 lb./in.^{2} abs. If it expanded according to Boyle's law, reaching a volume of 10.64 cu. ft. at 14.4 lb./in.^{2} abs., its pressure-volume relations would be represented by a straight line on the logarithmic chart having a slope of —1 and connecting points $P = 14.4$, $V = 10.64$, and $P = 2321$, $V = 10.64 \times \frac{14.4}{2321} = 0.066$. However, it is to be expected that this gas will be more compressible than an ideal gas.

Curve C, fig. 13, shows a gas-phase volume at 2321 lb./in.^{2} abs. of 0.059 cu. ft., which is equivalent to a deviation from Boyle's law of $\left(\frac{0.066}{0.059} - 1\right) 100 =$ 11.9 percent. This seems to be of the right order of magnitude when the deviations reported by Johnson and Berwald[18] and the effect of temperature on deviation are considered.

It may therefore be assumed that line E, fig. 13, between points $P = 2321$, $V = 0.059$, and $P = 14.4$, $V = 10.64$, represents the pressure-volume relations of the first 0.42 lb. of gas liberated from the bottom-hole sample (from 1 cu. ft. of liquid measured at 2829 lb./in.^{2} abs. and 149° F.) or the second 0.42 lb. liberated from the reservoir-fluid sample (1.0234 cu. ft. of reservoir liquid measured at 2829 lb./in.^{2} abs. and 149° F.). Also that this same line between the points $P = 2575$, $V = 0.053$, and $P = 14.4$, $V = 10.64$, represents the pressure-volume relations of the first 0.42 lb. of gas liberated from the reservoir-fluid sample. That is, it may be assumed that the 0.42 lb. of gas which must be absorbed into 1 cu. ft. of the bottom-hole sample (measured at 2829 lb./in.^{2} abs. and 149° F.) to make it identical with reservoir fluid will occupy a liquid volume of 0.0234 cu. ft. at 2829 lb./in.^{2} abs., expand along some path to the volume 0.053 cu. ft. in going completely into the gaseous phase as the pressure is reduced to 2575 lb./in.^{2} abs., and then expand along line E to point $P = 14.4$, $V = 10.64$, as the pressure is reduced to atmospheric.

The 70° F. bottom-hole oil is of the same composition as the 149° F. sample, but 1 cu. ft. measured at 70° F. is equivalent in mass to $\frac{1}{0.958} =$ 1.0438 cu. ft. measured at 149° F. Therefore, the quantity of gas required to bring 1 cu. ft. of the 70° F. bottom-hole oil to the composition of the reservoir fluid is 9.26 × 1.0438 = 9.67 cu. ft. on a 14.4 lb./in.^{2} abs. and 70° F. base (0.44 lb. of gas). From the 70° F. curve of fig. 7, this is $\frac{9.67}{0.7977} \times 5.615 =$ 68.1 cu. ft. of gas per bbl. of 70° F. residual oil, indicating that 664.8 + 68.1 = 732.9 cu. ft. of gas per bbl. of residual oil would be liberated from the reservoir fluid with 70° F. differential liberation.

The saturation pressure of the reservoir fluid at 70° F. may be estimated from the data of table 1, as plotted in fig. 7. One cu. ft. of bottom-hole oil measured at 2829 lb./in.^{2} abs. and 70° F. will have a volume of $\frac{1}{0.958} =$ 1.0438 cu. ft. at 149° F. Since 1 cu. ft. of 149° bottom-hole oil plus the lighter hydrocarbons added to bring it to reservoir-fluid composition occupies a volume of 1.0234 cu. ft. at 149° F. the above sample will occupy 1.0438 × 1.0234 = 1.0682 cu. ft. when the lost gas is added. Having now a higher coefficient of thermal expansion this reservoir fluid would have the volume 1.0682 × 0.957 = 1.0223 cu. ft. at 70° F. and 2829 lb./in.^{2} abs. pressure. Assuming that this reservoir fluid (liquid) has the same coefficient of decompression as the bottom-hole oil, its expansion with reduction in pressure would be along the line (on fig. 7) extending from the point $P = 2829$, $V = 102.23$, toward the point $P = 2050$, $V = 102.23 \times 100.97 = 103.22$. The saturation pressure would be reached at the point where this line intersects the extrapolated 70° F. shrinkage curve. Plotting on a large scale, or simultaneous solution of equations for the two lines, places this point of intersection at $P = 2273$, $V = 102.92$. The "gas in solution" at this point will be 732.9 cu. ft. per bbl. of residual oil. It may be estimated therefore that in flash liberation of a sample of 70° F. reservoir fluid occupying a volume of 1.0292 cu. ft. at its saturation pressure of 2273 lb./in.^{2} (equivalent to 1 cu. ft. of bottom-hole oil measured at 2829 lb./in.^{2} abs. and 70° F. plus its lost gas), 9.67 cu. ft. of gas measured on a 14.4 lb./in.^{2} abs. and 70° F. base (0.44 lb. of gas) will be liberated between the pressures of 2273 and 2050 lb./in.^{2} abs. and a second 9.67 cu. ft. will be liberated between the pressures of 2050 and 1827 lb./in.^{2} absolute.

Curve D, fig. 13, indicates a volume of the gas phase of 0.060 cu. ft. at the pressure of 1827 lb./in.^{2} abs. Based on a volume of 9.67 cu. ft. at 14.4 lb./in.^{2} abs. this is equivalent to a deviation of about 28 percent from Boyle's law. Although this deviation is large it is of the right order of magnitude for the pressure and temperature involved.[19]

Therefore, line F, fig. 13, between the pressures 1827 and 14.4 lb./in.^{2} abs. may be taken as a fair representation of the pressure-volume relations for the first 0.44 lb. of gas liberated from the 70° F. bottom-hole sample, or the second from the reservoir-fluid sample, and that same line between the pressures 2050 and 14.4 lb./in.^{2} abs. may be considered to represent the relations for the first 0.44 lb. of gas liberated from the reservoir-fluid sample.

The extrapolated 70° F. shrinkage curve of fig. 7 gives a volume of 1.0292 cu. ft. for the saturated reservoir fluid at 2273 lb./in.^{2} abs. and

[18] Johnson, T. W., and Berwald, W. B., Deviation of Natural Gas from Boyle's Law: Tech. Paper 539, Bureau of Mines, 1932, 29 pp.

[19] See footnote 18.

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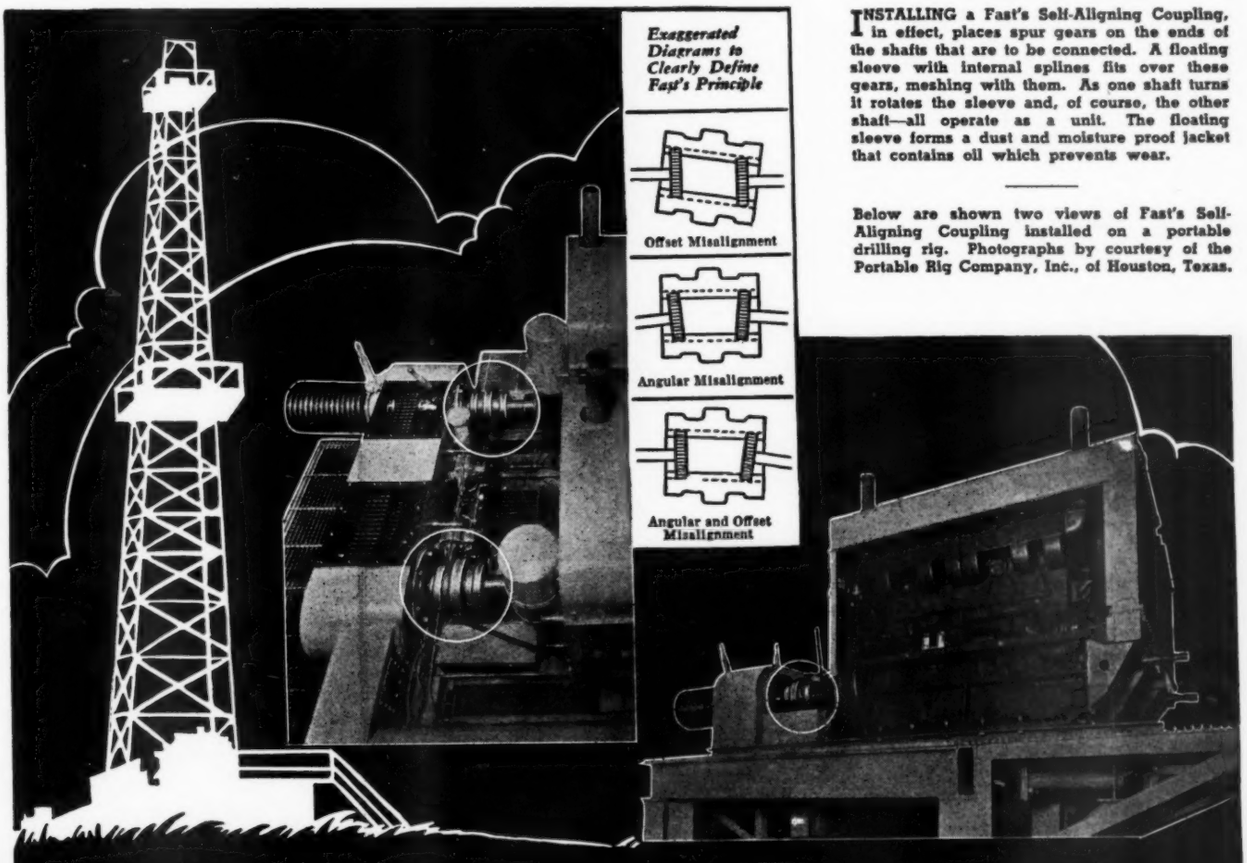

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the liquid expansion line gives a volume of 1.0069 cu. ft. for the 70° F. bottom-hole oil at the same pressure. Thus the 0.44 lb. of gas required to bring the sample of bottom-hole oil to the reservoir-fluid composition may be considered to occupy a liquid volume at 2273 lb./in.² abs. of 1.0292 — 1.0069 = 0.0223 cu. ft. As previously indicated, the 70° F. sample of reservoir fluid has a volume of 1.0223 cu. ft. at 2829 lb./in.² and has a mass which is 1.0438 times that of the 149° F. reservoir fluid sample occupying 1.0234 cu. ft. at the same pressure. The volume of 70° F. sample, which is equivalent to the 149° F. sample in mass, is $\frac{1.0223}{1.0438}$ = 0.9794 cu. ft., and if the temperature is increased from 70 to 149° F. this volume will become $\frac{0.9794}{0.957}$ = 1.0234 cu. ft.

In constructing curve *G*, fig. 13, the volumes (from line *E*) of the 0.42 lb. of gas required to bring the 1 cu. ft. (45.8 lb.) of 149° F. bottom-hole oil to reservoir-fluid composition were added to the volumes of the bottom-hole sample shown by curve $A_1A_2A_3$. This gave the volumes at various pressures of a quantity of fluid composed at 2829 lb./in.² abs. and 149° F. of 1.000 cu. ft. of bottom-hole sample plus 0.0234 cu. ft. of liquid resulting from absorption of the 0.42 lb. of gas. Therefore, to base curve *G* on the quantity of reservoir fluid occupying 1 cu. ft. at 2829 lb./in.² abs. and 149° F., each volume obtained by the above-mentioned addition was divided by 1.0234. Table 9 shows the computation of some of the points on curve *G*.

Table 9. Illustrating Computation of Points on Curve G, fig. 13

(1) Pressure, lb./in.² abs.	(2) Volume from $A_1A_2A_3$, cu. ft.	(3) Volume from E, cu. ft.	(4) Volume (2) + (3), cu. ft.	(5) Volume for plotting G (4) ÷ 1.0234, cu. ft.
2829	1.000	0.0234	1.0234	1.000
2575	1.0025	.053	1.0555	1.031
2321	1.038	.059	1.097	1.072
1600	1.25	.086	1.336	1.305
500	3.37	.29	3.66	3.58
14.4	144.1	10.64	154.74	151.2

In a like manner curve *H*, fig. 13, was constructed by adding volumes read from line *F* to volumes read from curve $B_1B_2B_3$ and multiplying these sums by $\frac{0.957}{1.0223}$, thus bringing the initial point of curve *H* to a volume of 0.957 cu. ft. at 2829 lb./in.² abs. Therefore, on the basis of the estimate that the reservoir fluid shrinks 4.3 percent in volume as the result of a reduction in temperature from 149° to 70° F. at 2829 lb./in.² abs., curves *G* and *H* represent isothermal pressure-volume relations at 149° and 70° F., respectively, of the same mass of reservoir fluid—the mass of liquid occupying a volume of 1 cu. ft. at 2829 lb./in.² abs. and 149° F. This would weigh $\frac{45.8 + .42}{1.0234}$ = 45.2 lb.

Since the method illustrated by fig. 13 for drawing estimated *PV* curves for the reservoir fluid was not contemplated at the time the tests were made, having been suggested by Cattell[20] subsequently, the experimental data taken are not entirely adequate for accurate construction of the upper ends of curves *C* and *D*. In another test the saturation-pressure determinations (fig. 6) could be modified somewhat and carried to lower pressures, thus giving better data for construction of these curves. In any event, the small angle between curves *C* and *D* and the pressure lines will introduce uncertainties in determining the exact points of intersection, but it will be noted that he upper ends of lines *E* and *F* may be shifted a considerable distance to the right or left without any considerable effect on the shapes of curves *G* and *H* or the values of the indicated work determined from them.

APPENDIX B

Estimates of Gas Evolved and Shrinkage of Liquid with Flash Liberation

The shrinkage of oil resulting from liberation of gas is not proportional to the volume of gas liberated when there is variation in gas composition; that is, the shrinkage depends upon both volume and composition of the liberated gas. However, in the instances discussed below the assumption that the shrinkage is proportional to the gas liberated may be used to obtain fair approximations of shrinkage and of gas evolved per unit volume of residual oil with flash liberation.

For bottom-hole oil. In the flash liberation test at 149° F. (curve $A_1A_2A_3$, fig. 13) the volume of the sample at 14.4 lb./in.² abs. is 144.1 cu. ft., of which approximately 0.7 cu. ft. is liquid and 143.4 cu. ft. gas. This volume of gas is equivalent to 143.4 $\frac{530}{609}$ = 124.8 cu. ft. of gas (14.4 lb./in.² abs. and 70° F. base) per cu. ft. of initial oil, or 124.8 × 5.615 = 700.8 cu. ft. of gas per bbl. of initial oil, to be compared with 579.3 cu. ft. per bbl. initial oil in differential liberation (table 6). The 28.83-percent shrinkage with differential liberation shown by the 149° F. curve of fig. 7 may be divided approximately into 26.01 percent due to gas liberation and 2.82 percent (3.8 percent of residual oil) due to thermal shrinkage of the residual oil. Assuming that the shrinkages in flash and differential liberations at 149° F. are proportional to the gas liberated per unit volume of initial fluid the shrinkage with flash liberation is estimated to be 26.01 × $\frac{700.8}{579.3}$ + 2.82 = 34.28 percent. On the basis of that estimate, 1 bbl. of initial fluid would yield 1.0000 — 0.3428 = 0.6572 bbl. of residual oil, and the gas liberated per bbl. of residual oil would be $\frac{700.8}{0.6572}$ = 1066.3 cu. ft. (14.4 lb./in.² abs. and 70° F. base.).

In the flash-liberation test at 70° F. (curve $B_1B_2B_3$, fig. 13) the initial volume is 1 cu. ft. of liquid measured at 2829 lb./in.² abs. and 70° F., equivalent to $\frac{1}{0.958}$ cu. ft. measured at 2829 lb./in.² abs. and 149° F., and the final volume is 91.3 cu. ft., of which approximately 0.8 cu. ft. is liquid and 90.5 cu. ft. gas. Thus the gas liberated is 90.5 × 5.615 = 508.2 cu. ft. (14.4 lb./in.² abs. and 70° F. base) per bbl. of initial oil measured at 2829 lb./in.² abs. and 70° F., which is equivalent to 508.2 × 0.958 = 486.9 cu. ft. of gas per bbl. of initial oil measured at 2829 lb./in.² abs. and 149° F. In differential liberation at 70° F. the shrinkage was 20.23 percent (table 1 and fig. 7), and 664.83 (100 — 20.23) = 530 cu. ft. of gas (14.4 lb./in.² abs. and 70° F. base) was liberated per bbl. of initial oil measured at 2829 lb./in.² abs. and 70° F. (table 5). The shrinkage with flash liberation at 70° F. may therefore be estimated at 20.23 × $\frac{508.2}{530}$ = 19.4 percent. One bbl. of initial oil (at 70° F.) then would yield 1.00 — 0.194 = 0.806 bbl. of residual oil, and the gas liberated per bbl. of residual oil would be $\frac{508.2}{0.806}$ = 630.5 cu. ft. (14.4 lb./in.² abs. and 70° F. base).

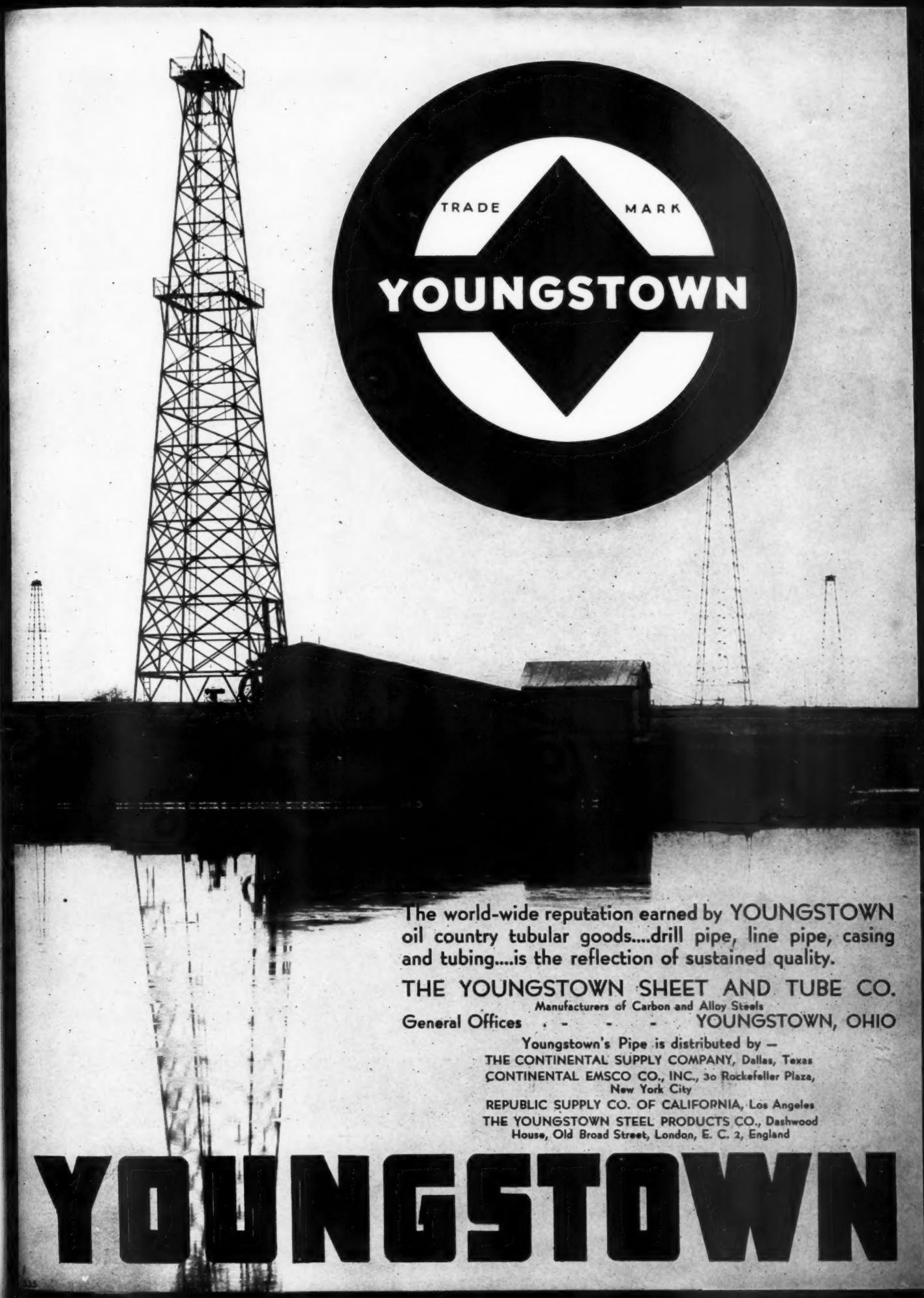
For reservoir fluid. Computations given earlier in this report indicated a shrinkage of 30.46 percent (p. 39, March issue) and a gas liberation of 617 cu. ft. (14.4 lb./in.² abs. and 70° F. base) (table 3), per bbl. of reservoir fluid expanded isothermally at 149° F. with differential liberation. This 30.46-percent shrinkage may be divided approximately into 27.41 percent due to gas liberation and 3.05 percent due to thermal shrinkage of the residual oil. In the flash expansion of reservoir fluid at 149° F. (curve *G*, fig. 13), starting with 1 cu. ft. of fluid at 2829 lb./in.² abs. and 149° F., the final volume is 151.2 cu. ft., of which about 0.7 cu. ft. is liquid and 150.5 cu. ft. gas. This gas, reduced to a 14.4 lb./in.² abs. and 70° F. base, is 150.5 × $\frac{530}{609}$ = 131.0 cu. ft. per cubic foot of initial oil or 131.0 × 5.615 = 735.6 cu. ft. per bbl. of initial oil. The shrinkage of the reservoir fluid with 149° F. flash liberation may be estimated as $\left((27.41 \times \frac{735.6}{617}\right) + 3.05 = 35.73$ percent, giving a gas liberation of $\frac{735.6}{0.6427}$ = 1144.5 cu. ft. of gas (14.4 lb./in.² abs. and 70° F. base) per bbl. of residual oil.

In 70° F. differential liberation 1.0223 cu. ft. of reservoir oil, measured at 2829 lb./in.² abs. and 70° F., yield 0.7977 cu. ft. of residual oil and liberates 732.9 × 0.7977 = 584.6 cu. ft. of gas (14.4 lb./in.² abs. and 70° F. base) (see pp. 131 and 132). The shrinkage is therefore 100 — $\frac{79.77}{1.0223}$ = 21.97 percent, and the gas liberated is $\frac{584.6}{1.0223}$ = 571.8 cu. ft. per bbl. of initial fluid measured at 2829 lb./in.² abs. and 70° F. or 571.8 × .957 = 547.2 cu. ft. per bbl. of initial oil measured at 2829 lb./in.² abs. and 149° fahrenheit.

In the flash liberation of reservoir fluid at 70° F. (curve *H*, fig. 13) the initial volume is 0.957 cu. ft., and the final volume is 94.5 cu. ft., of which about 0.7 cu. ft. is liquid and 93.8 cu. ft. gas. Thus the gas liberated is about 93.8 × 5.615 = 527 cu. ft. (14.4 lb./in.² abs. and 70° F. base) per bbl. of initial fluid measured at 2829 lb./in.² abs. and 149° F. (per 0.957 bbl. measured at 2829 lb./in.² abs. and 70° F.) Therefore the shrinkage with flash liberation may be estimated as 22.05 × $\frac{527}{547.2}$ = 21.2 percent, giving a residual oil volume of 0.957 (1.000 — .212) = 0.754 cubic feet.

In the flash liberation with the temperature falling from 149° to 70° F. (curve *KL*, fig. 13) the initial cubic foot of reservoir fluid yields 0.754 cu. ft. of residual oil and 93.8 cu. ft. of gas. The shrinkage may therefore be estimated as 24.6 percent and the gas liberated as 93.8 × 5.615 = 526.7 cu. ft. per bbl. of initial fluid, or $\frac{526.7}{0.754}$ = 698.5 cu. ft. per bbl. of residual oil.

[20] See footnote 16.



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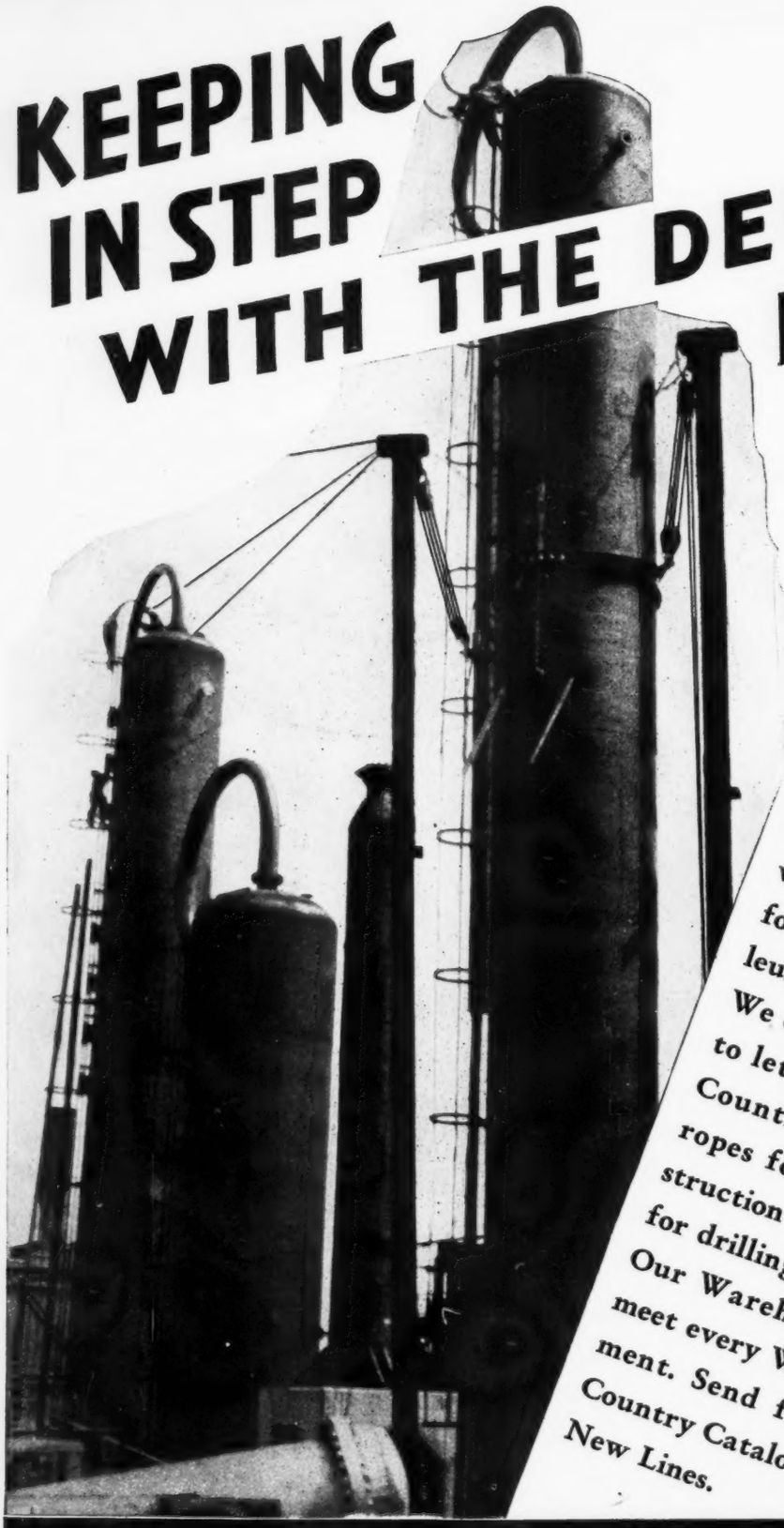

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PICTORIAL PETROLEUM

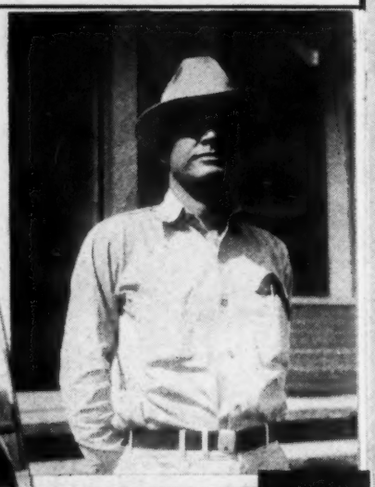
JUNE, 1936

Lights from the Texas Centennial Central Exposition grounds reflected in White Rock Lake, Dallas. The State's Centennial year also marks the seventieth anniversary of the discovery of oil in Texas.

A regular feature of The Petroleum Engineer

Group of Pelican Oil and Gasoline Company employees taken at Rodessa, Louisiana. Left to right: R. D. Ruhlman, production clerk; L. D. Phillips, gasoline plant superintendent; V. W. Hess, production engineer; R. D. Morgan, assistant plant superintendent; L. M. Gay, engineer; L. O. Neeley, plant clerk; Wm. H. Vaughan, general superintendent, and E. E. Lee, Haywood Machinery Company, Inc.

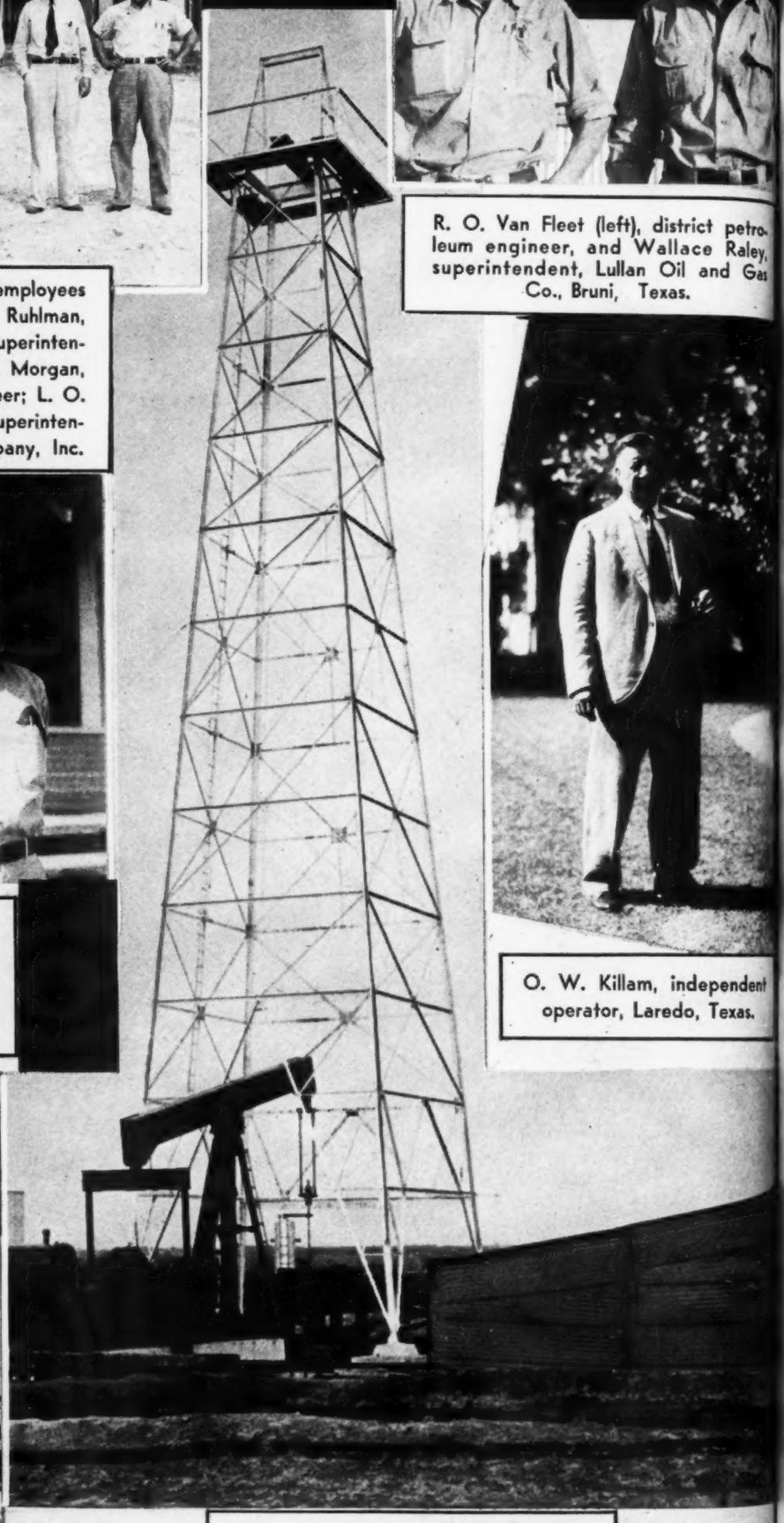
R. O. Van Fleet (left), district petroleum engineer, and Wallace Raley, superintendent, Lullan Oil and Gas Co., Bruni, Texas.



Left: R. W. Roach, tool pusher, Freer, Texas. Right: F. W. Roberts, superintendent, Lullan Oil and Gas Company, Kennedy, Texas.

O. W. Killam, independent operator, Laredo, Texas.

Below: C. V. Sidwell (left), general superintendent production, British American Oil Company, Tulsa, Okla., and J. C. Bruce, field superintendent at Oklahoma City for the same company.



Discovery well in Talco, Texas, field, owned by Pleasant Oil Co. The pumping unit is a Lufkin.

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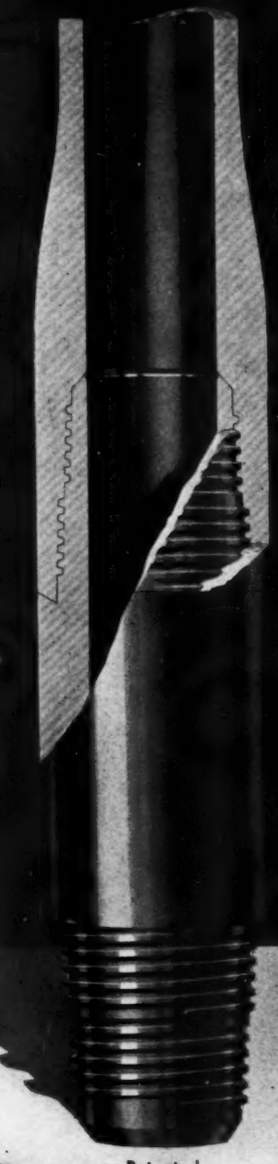

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This top-notcher is the Hydril Internal Flush Drill Pipe Joint itself! He sells on merit alone, he makes friends and REPEAT CUSTOMERS. The continual repeat orders by major oil companies for Hydril Internal Flush Drill Pipe Joints for use in drilling deep wells is a good example of his selling ability. This is his sales talk:

The size of the hole through the tool joints is the same as the full inside diameter of the drill pipe itself, in all sizes from 2 3/8-inch up. The joint is fluid and gas tight, non-creeping, and the strongest drill pipe joint in the industry.

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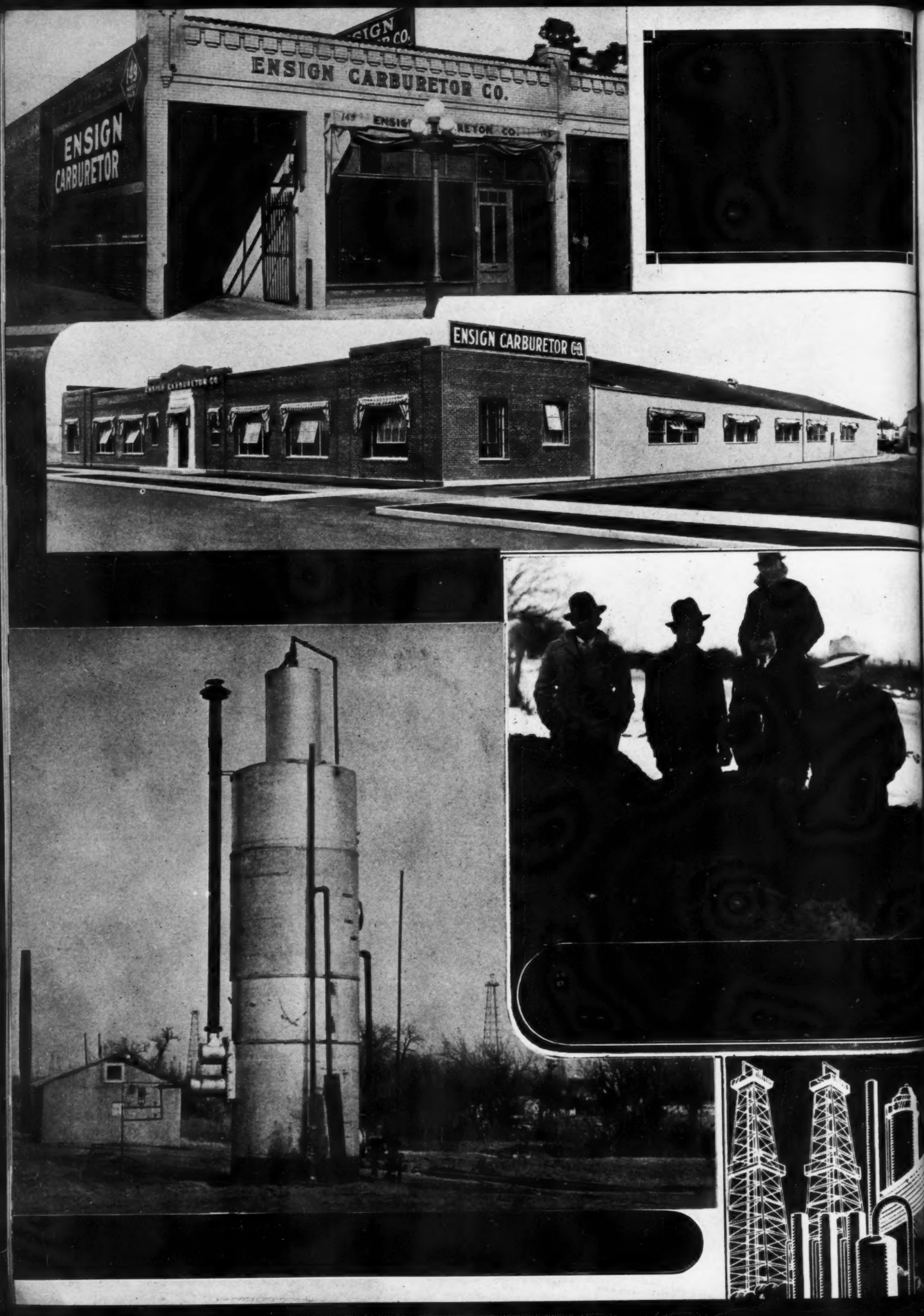
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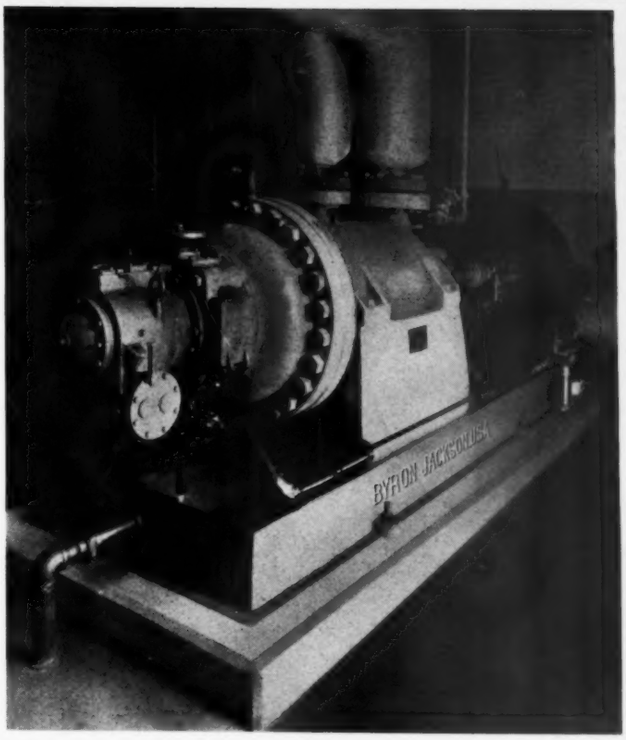
It's the that tell the story of

Re-orders always follow the installation of the first Byron Jackson Hot Oil Charging Pump in a refinery. And it is the day-by-day performance of the first pump, its low operating cost, dependable quality and safety factors that cause Byron Jackson to be specified when need for additional hot oil charging equipment develops.

A case in point is the Continental Oil Company. The record of a Byron Jackson Hot Oil Charging Pump at their Ponca City refinery was the determining factor when the company required another pump for its Denver plant.

Refineries especially endorse this pump because the rotating element can be removed from the inner volute without disassembling the impellers on the shaft. The horizontally split inner volute, patented double case construction, makes it possible to disassemble easily for inspection or repair; even the stage pieces, used to prevent wear on the inner case, are split, permitting replacements without removing the impellers from the shaft.

These features are found only in the Byron Jackson Hot Oil Charging Pump.



The upper picture shows one of the two 1050-lb., 10-stage, double case Byron Jackson Hot Oil Charging Pumps, operating in the Ponca City plant of the Continental Oil Company. The lower picture shows back-to-back arrangement of the impellers.

Builders of centrifugal pumps for every refinery service.

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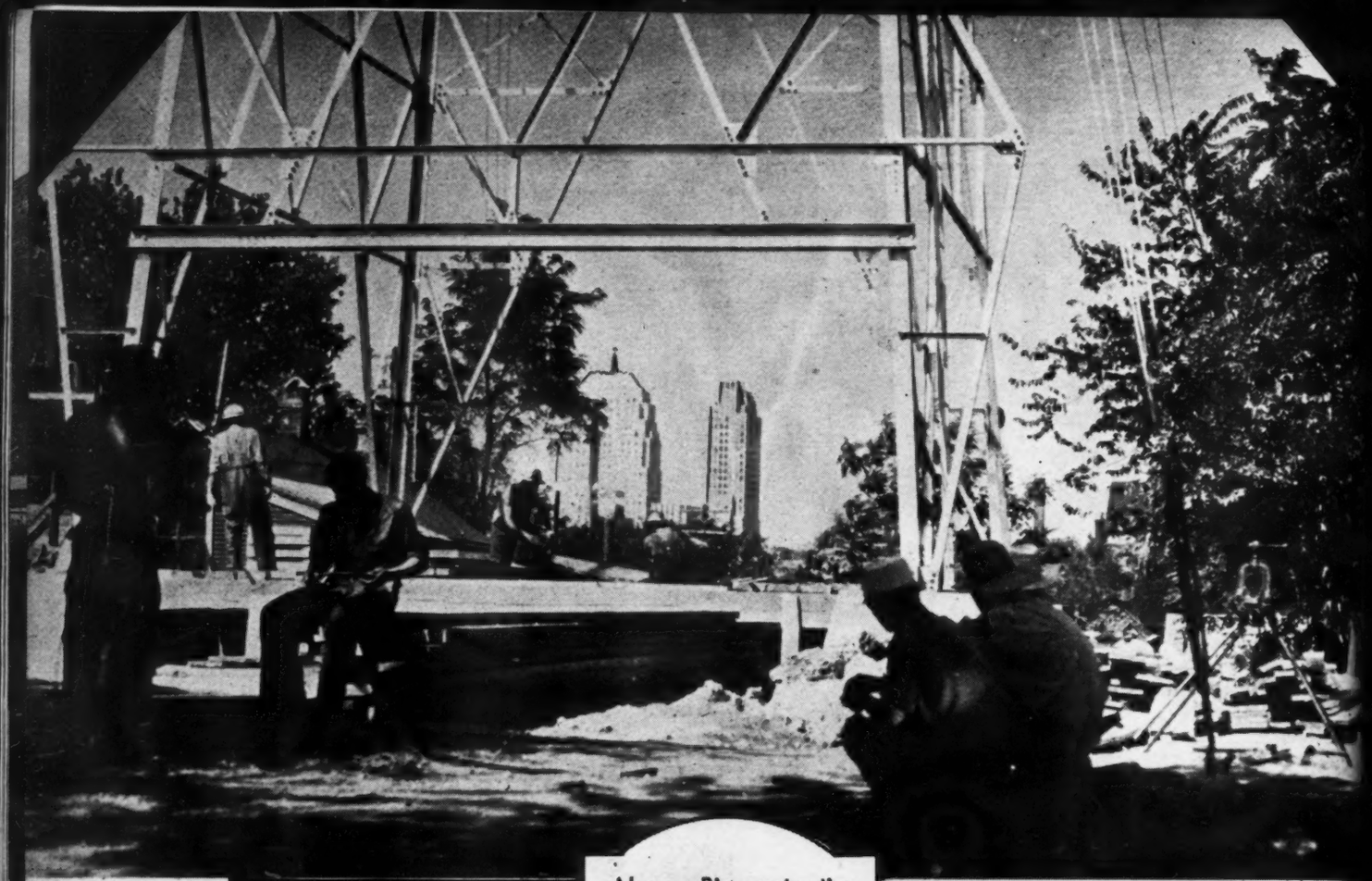
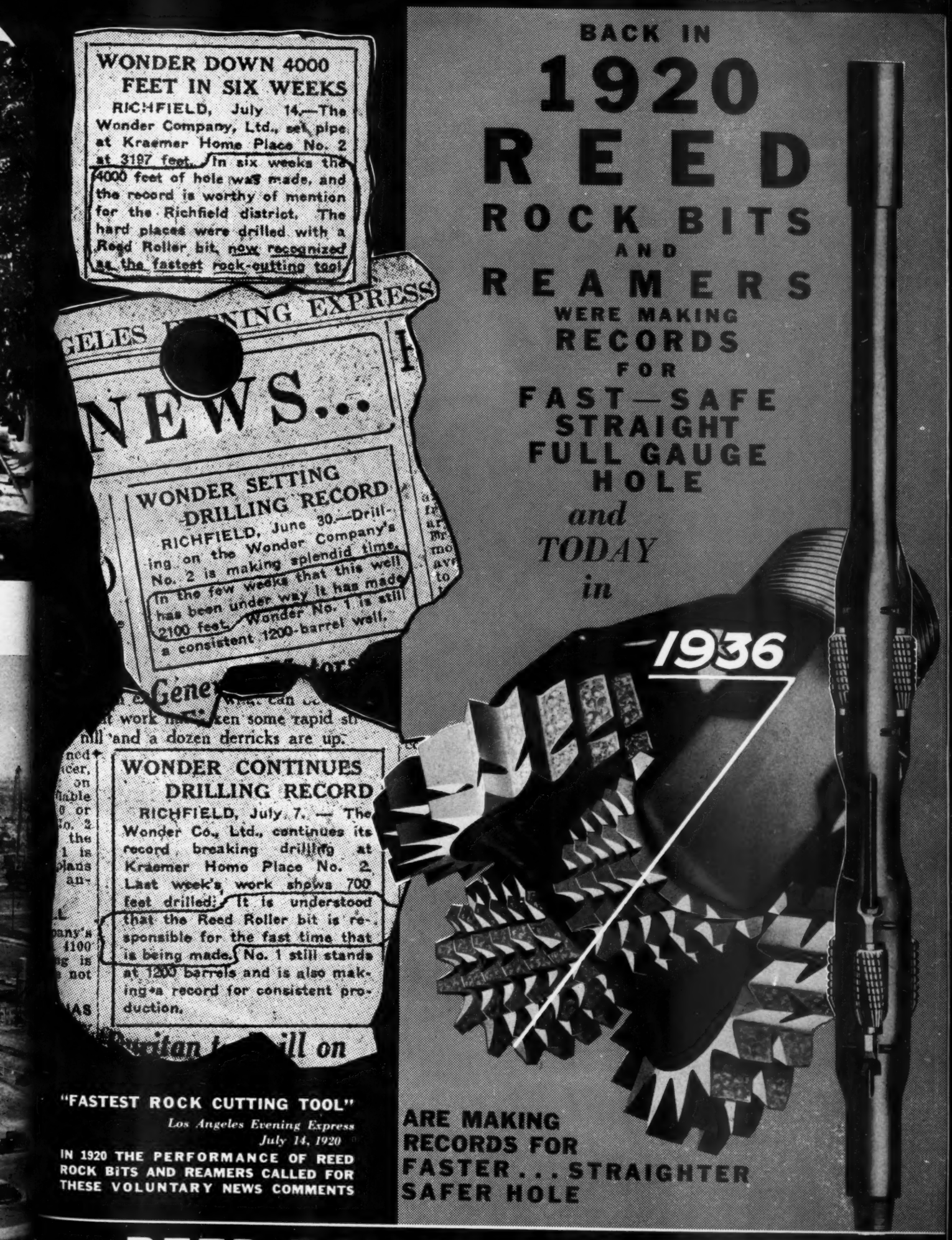


Above: Rig construction in Oklahoma City field. Below: New townlot development in Oklahoma City. View taken from top of State Capitol building.


WONDER DOWN 4000 FEET IN SIX WEEKS
RICHFIELD, July 14.—The Wonder Company, Ltd., set pipe at Kraemer Home Place No. 2 at 3197 feet. In six weeks the 4000 feet of hole was made, and the record is worthy of mention for the Richfield district. The hard places were drilled with a Reed Roller bit, now recognized as the fastest rock-cutting tool.
NEWS...
WONDER SETTING DRILLING RECORD
RICHFIELD, June 30.—Drilling on the Wonder Company's No. 2 is making splendid time. In the few weeks that this well has been under way it has made 2100 feet. Wonder No. 1 is still a consistent 1200-barrel well.
WONDER CONTINUES DRILLING RECORD
RICHFIELD, July 7. — The Wonder Co., Ltd., continues its record breaking drilling at Kraemer Home Place No. 2. Last week's work shows 700 feet drilled. It is understood that the Reed Roller bit is responsible for the fast time that is being made. No. 1 still stands at 1200 barrels and is also making a record for consistent production.
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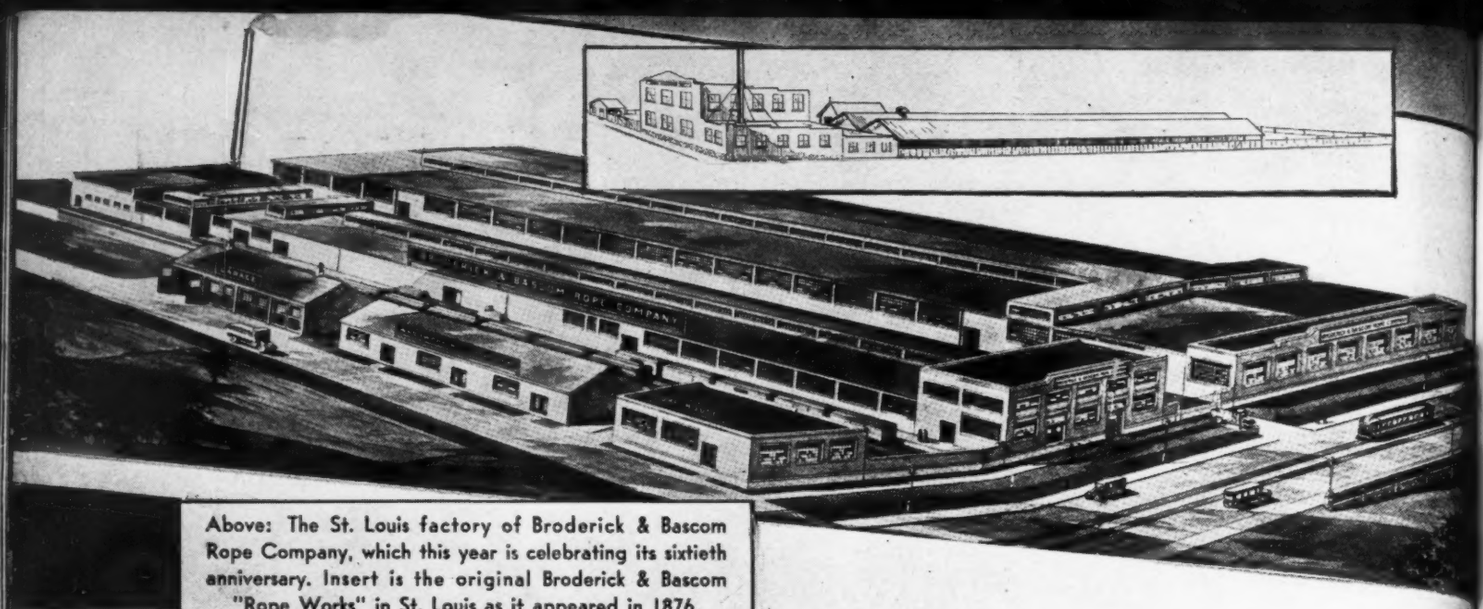
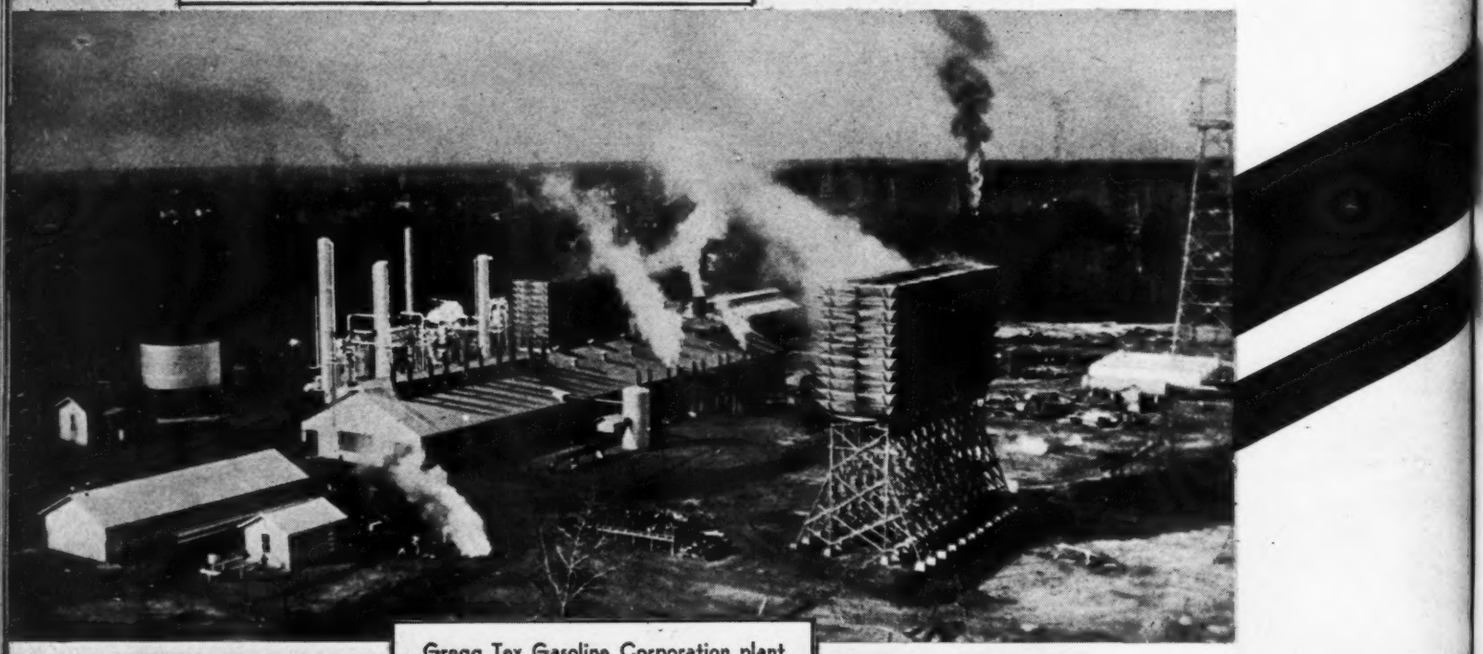


Above: The St. Louis factory of Broderick & Bascom Rope Company, which this year is celebrating its sixtieth anniversary. Insert is the original Broderick & Bascom "Rope Works" in St. Louis as it appeared in 1876.



Gregg Tex Gasoline Corporation plant near Longview, Texas.

Operating personnel of Gregg Tex Gasoline Corporation plant, Longview, Texas. Bottom row, left to right: H. L. Baber, operator; C. D. Hearnsberger, engineer; E. W. Burt, chief operator; J. R. Epperson, chief engineer; Pat Gathright, truck driver; Earl McCracken, clerk; L. L. Lee, flow schedule; Clayton Domangue; and H. B. Blackwell. Top row, left to right: J. L. Ravenscraft; S. B. Young, oiler; K. L. Pyle, mechanic; J. T. Smith, assistant engineer; J. G. Keonning; D. C. Couch; George W. Graham, draftsman; H. H. Hartness; Virgil Wallace, chart collector; Jack Moberly, chart collector; and Jeff Carmack, chart collector.

Daniel E. Sullivan (left), chief engineer, Pure Oil Company, Chicago, and G. L. Griffin, vice-president, Chapman Valve Manufacturing Company, Indian Orchard, Mass.

It COSTS LESS to drill FULL GAUGE HOLE faster and straighter with a GLOBE Type B-3 BIT

The continuing popularity of the globe B-3 Bit—it has been a favorite since 1927—is due to its ability to cut STRAIGHT hole at a low cost per foot in a wide variety of formations. The stepped teeth cut a short core which prevents the bit from "walking" and eliminates "diamond pointing."

FAST-CUTTING TEETH

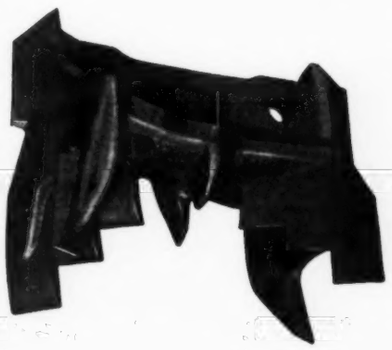
The angle at which the teeth are set has been worked out through years of experience in cutting many formations. Each tooth meets with a minimum of resistance in breaking up the short core, thus increasing drilling speed.

FULL GUAGE HOLE

Two lower cutting blades and one upper reaming edge on each side of the B-3 Bit Head provide a total of six reaming edges that continuously contact and round out the wall of the hole. (See sketch.) It is not necessary to ream hole made by the B-3 Bit to get to bottom with a sharp bit or core barrel.

SAFE BIT HEAD

The replaceable molybdenum steel heads are provided with heavy horizontal shoulders which carry all the weight of drilling, while the torque is transmitted through the bearing forces on the vertical bar. The retaining bolts bear no weight or side thrust. These safe heads stand repeated rebuilding, the reinforcing ribs preventing warping of teeth.



STRONG SHANK

The heat treated alloy steel shank is furnished in both a short type (illustrated) and a long design. Four replaceable circulation nipples direct the fluid against the cutting edges of the blades, cleaning them and removing cuttings from the bottom of the hole.

THIS CORE assists in guiding the Globe B-3 Bit straight while it economically cuts the formation. The core is quickly destroyed by the successive rows of "stepped" teeth which attack it from the most advantageous cutting angle.

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GLOBE OIL TOOLS

FRANK BREWSTER, president of the Belmont Quadrangle Drilling Corporation, Bradford, Pennsylvania, and **J. A. THOMPSON,** engineer with the same company, were visitors in Dallas recently, attending the American Gas Association meeting, later going to Tulsa for the International Petroleum Exposition.

MORGAN WALKER, chief petroleum engineer of the Lago Petroleum Corporation, literally made a flying trip to the States recently. He left his headquarters at Maracaibo, Venezuela, on a Saturday morning by plane, arriving in Dallas, Texas, Monday at 2:00 p. m., and going on to Tulsa that night by train. He spent two days in Tulsa and returned to Maracaibo by plane, arriving there on Saturday—being away from headquarters but one week.

R. W. HENDEE, who has been president of the Oklahoma Natural Gas Company for a number of years, has resigned to accept a prominent position with the Colorado Interstate Gas Company at Colorado Springs, Colorado. He is being succeeded by **JOSEPH BOWES,** executive with Webster & Stone, a major utility organization.

G. C. CULTER, who has been a petroleum engineer with the Sinclair Prairie Oil Company at Shidler, Oklahoma, has resigned to become a drilling contractor, being a member of the firm of Byrne & Culter, with headquarters at Tulsa, Oklahoma. **JOHN BYRNE** is the other member of the firm.

GEORGE W. HANNEKEN has been appointed general manager of the manufacturing department of the Standard Oil Company of Ohio, it has been announced by **W. T. HOLLIDAY,** president. Henneken, who has been superintendent of the company's Toledo refinery since its establishment in 1919, assumes the functions administered by **LESTER S. BALE** prior to his recent death.

JOHN M. SWEENEY, production foreman for the Sun Oil Company, has been transferred from Kilgore, in the East Texas field, to the company's production division at Odessa, Texas.

E. L. DAVENPORT, formerly division superintendent for the Shell Petroleum Corporation, now producing independently, recently returned from Washington, D. C., and other points, where he went on business.

OWEN GOSNELL, producton superintendent for the National Refining Company in Tulsa, Pawnee, Creek, and Osage counties, with headquarters at Keystone, Oklahoma, has been elevated to production superintendent in western Kansas and will have his headquarters at Russell.

N. H. MOORE, district superintendent in South Texas for Empire Gas and Fuel Company, resigned, effective June 1st. **S. T. DUREE,** who is in charge of operations at Darst Creek and Somerset, has extended his supervision to the Gulf Coast area, and both districts have been placed in charge of **F. A. LAWRENCE,** division superintendent for East Texas and Arkansas, with headquarters at Gladewater, Tex.

SALVADOR DEL RIO, petroleum engineer with the Huasteca Petroleum Company, at Tampico, Mexico, spent his vacation in the United States.

SIDNEY KILBEY, an executive with the Cia. Mexicana de Petroleo "El Aguila" S. A. (Royal Dutch Shell), at Tampico, Mexico, is taking a vacation in Europe where he will remain for three months.

MARSHALL JOY has been sent from the Bartlesville, Oklahoma, office of the Empire Oil and Refining Company to Seminole where he is the new assistant district superintendent. **J. L. BOLE** succeeds Joy at Bartlesville.

WILLIAM MOELLER, JR., vice-president of the Southern California Gas Company, is now back at his headquarters in Los Angeles after making a trip to Dallas, Texas, for the purpose of delivering the opening address at the American Gas Assocation convention.

J. EDGAR PEW, Philadelphia, Pennsylvania, vice-president in charge of production for the Sun Oil Company, recently visited the Dallas, Texas, offices of the company.

L. E. FOUST, who has been superintendent of the Associated Oil Company's lower San Joaquin Valley division, has been transferred to San Francisco where he will be connected with the land department.

W. L. BOOSA, who has been a production engineer for the Empire Oil and Refining Company in the Seminole, Oklahoma, area, has been transferred to the Bartlesville, Oklahoma, office. **H. V. ANDERSON** has been sent from Bartlesville to Electra, Texas, where he will be in charge of production engineering in the North Texas and Southern Oklahoma districts.

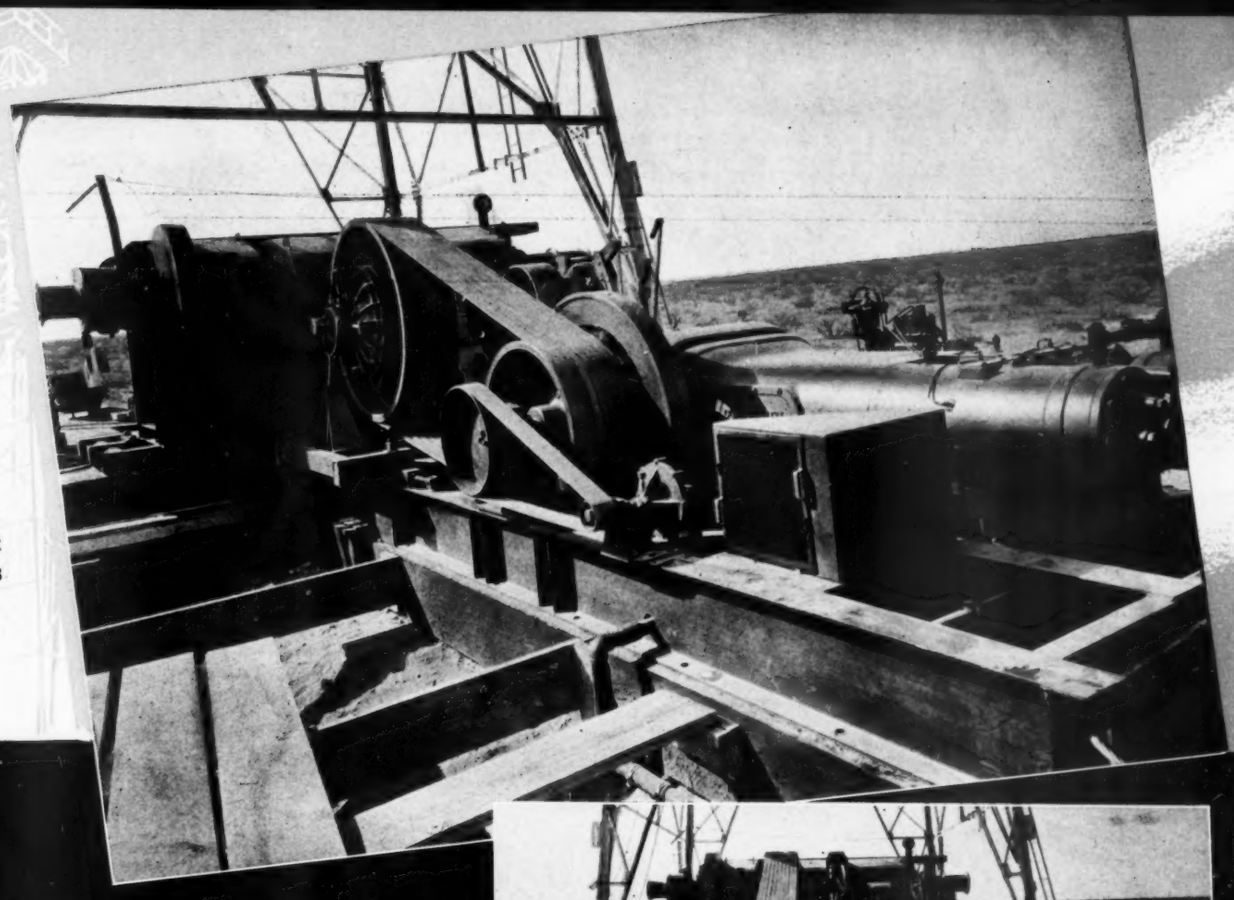
F. J. WESTBURY, production engineer for Trinidad Petroleum Development Company, recently returned to Trinidad following a trip to London, England.

SIR LOUIS KERSHAW has been elected a member of the board of the Burmah Oil Company, filling a vacancy created by the recent death of **DR. LEONARD GOW.**

A. F. DRISKILL, of the Iraq Petroleum Company, Kirkuk, Iraq, is in the United States. He expects to be here until August, and will spend most of his time in California.

LAFE TODD, formerly general superintendent of pipe lines for the northern division of the Union Oil Company, has been promoted to the general superintendency of all pipe lines for the company. **W. W. HAY,** superintendent of the Los Angeles pipe line, has been made manager of all pipe line operations and will have his headquarters at Los Angeles. **R. V. ROSBOROUGH,** supervisor of pipe line operations the Los Angeles Basin has been transferred to San Luis Obispo and is superintendent of the northern division, being in charge of production as well as the Lompoc pipe lines. **J. H. ROBINSON** has succeeded to the post vacated by W. W. Hay and is making his headquarters at Brea.

CHARLES W. TREATER, Michigan independent operator, has established offices in Saginaw. He recently returned from a trip to the Orient.



Drive side of drawworks unit on West Texas installation.

FAIRBANKS-MORSE *Continental*

Drilling Contractors

The Fairbanks-Morse-Continental Twin Drilling Engine incorporates all the features of a sturdy, rugged, dependable engine—its simplicity of design makes it easy to understand and economical to operate.

Mounted on portable steel base with fuel, air, water and exhaust auxiliaries completely mounted.

Convertible for Cable Tool or Rotary service.

DRAWWORKS DRIVE

Engine and countershaft mounted on long base for butting to derrick sill. V-Belt or Flat Belt Drive from engine to countershaft.

SLUSH PUMP DRIVE

Short base power unit. V-Belt or Flat Belt Drive.

THE CONTINENTAL SUPPLY COMPANY

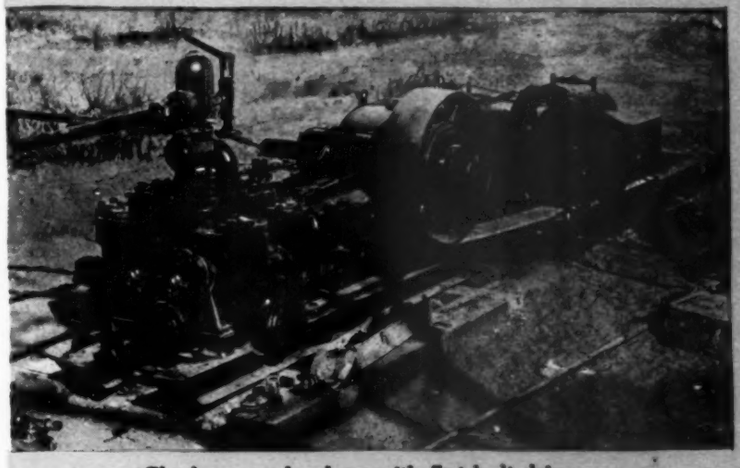
General Offices: DALLAS, TEXAS

Export Office: CONTINENTAL EMSCO CO., Inc.
30 Rockefeller Plaza New York City, N. Y.

Representatives:
LONDON MARACAIBO PLOESTI BUENOS AIRES

"Serving the Oil and Gas Industries"

Cylinder end of power unit showing chain drive to drawworks.



Slush pump hookup with flat belt drive.

CONTINENTAL

LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

"Young lady, I'd like to give you a complete physical examination."

"But, Doctor Smith examined me last week and found me perfect."

"So he told me."

* * *

Irate father (discovering his daughter on young man's lap): "Mary! What does this mean?"

Daughter: "Come back in about fifteen minutes, Dad. I ought to know by then."—*Cornell Widow.*

* * *

Mrs. Smith (showing portrait of herself in her mother's arms): "This is how I looked twenty years ago."

Guest: "Wonderful! And who is the baby on your arm?"

—*West Point Pointer.*

* * *

Perhaps one of the reasons why there are fewer train wrecks than there are automobile crashes, is due to the fact that the engineer seldom, if ever, tries to neck the fireman!

* * *

"I just saw a beautiful girl having trouble with her car back up that country road a-ways."

"Well, why didn't you stop and ask her if you could help?"

"I would have, but darn the luck, I don't know anything about autos."

* * *

"Men," he cried, "there is an announcement I want to make. Last night my wife presented me with a son."

The men broke ranks, cheered, threw their hats in the air, and general pandemonium reigned for nearly five minutes. When order had been restored, the Colonel, pleased with the enthusiastic reception of his announcement and the congratulations, indicated that he had another announcement:

"Men and officers," he said, clearing his throat, "I thank you."

* * *

Mrs. Flip: Are you troubled very much in your neighborhood with borrowing?

Mrs. Flop: Yes, a great deal. My neighbors don't seem to have anything I want.

"May I see the doctor?" asked the young man.

The young lady consulted her appointment book. "I think he'll be able to see you in thirty minutes. In the meantime, would you mind taking your clothes off?"

Thirty minutes later the doctor entered his office, to find a young man awaiting him in the raw.

"And what can I do for you?" he asked benignly.

"I came to see you," was the reply, "about renewing your wife's subscription to the Ladies' Home Companion!"

* * *

"We have a fire department in our town that has only one hose cart and two dogs."

"What are the dogs for?"

"To find the hydrants."

* * *

We were reading the other day about a girl who had a hitch-hike wedding. Just before the ceremony there was a hitch—the groom hiked.

* * *

Did you hear about the absent-minded office boss who came in one morning, kissed his desk, and dusted off his stenographer?

* * *

Gertie (in doctor's office): "Is there anything wrong with me, Doc?"

Doc: "Yes, but it's trifling."

Gertie: "Oh, is that very wrong, Doc?"

* * *

The doctor was questioning the new nurse about her latest patient.

"Have you kept a chart of his progress," he said.

The nurse blushing replied: "No, but I can show you my diary."

* * *

Then there were the two girls talking things over. One said, "Have you ever been x-rayed?" and the other replied, "No, but I've been ultra-violated."—*Ballyhoo.*

* * *

Wife: That new couple next door seem very devoted. He kisses her every time they meet. Why don't you do that?

Husband: I don't know her well enough yet.

Judge: Well, Jim, I can give you this divorce, but it will cost you $30.

Jim: Thirty dollars, boss?

Judge: Yes, that's the court fee for expenses.

Jim: Well, jedge, I don't believe I wants no divorce. There aint $30 difference between dem two wimmen.

—*Link-Belt News.*

* * *

Suitor: And where is your sister, Jimmy?

Jimmy: She just ran upstairs to change rings when she saw you coming.

* * *

Uncle Sam's Mistake

Young Wife (at post office window): I wish to complain about the service.

Postmaster: What is the trouble, Madam?

Young Wife: My husband is in Albany on business and the card he sent me is postmarked Atlantic City.

* * *

During an intense love scene in the movies, when the hero was doing his stuff, wifie nudged hubby and whispered:

"Why don't you ever make love to me like that?"

"Say," he replied, "do you know the salary that guy gets for doing that?"

* * *

Park Officer: Hey, come out of that pool! Don't you know that people have to drink that water?

Bum: Oh, dat's aw right, officer—I ain't usin' soap.

* * *

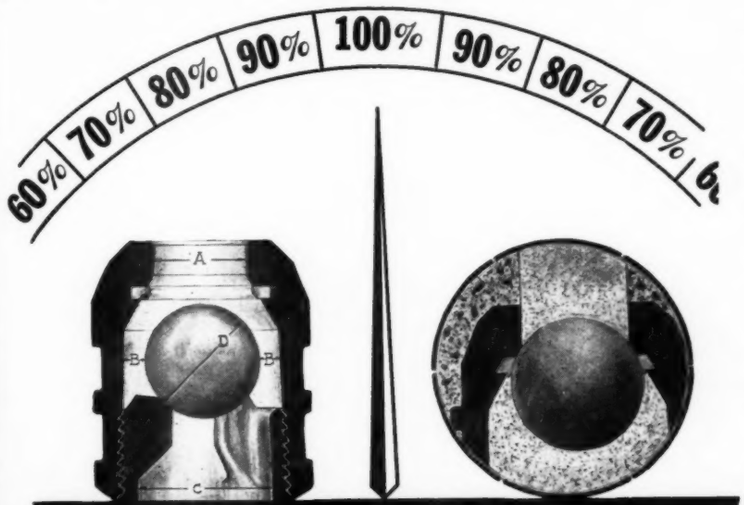
A dinner guest in a Virginia home was telling his host how to prepare ham that would be even better than the famous Virginia ham.

Guest: Place the ham in a deep pan and the first day soak it in a bottle of rye whiskey and let it cook awhile. The second day add a bottle of Jamaica rum and the third day a bottle of port wine and the fourth day a bottle of Bourbon.

Host (turning to the colored cook): What do you think of that, Sam?

Sam: Ah don't know 'bout de ham, but it sho' do sound like mighty fine gravy.

Use this Scale TO WEIGH THE SAFETY, EFFICIENCY AND TOTAL COSTS OF EQUIPMENT *for Guiding, Floating and Cementing* STRINGS OF CASING

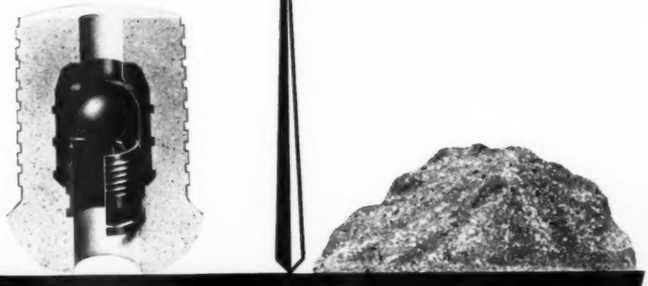


VALVE EFFICIENCY

ONLY when you carefully weigh all vital requirements of cementing equipment do you realize what the "Three-Point-Balance" of Baker Cement Equipment means to you.

When you consider Valve Efficiency notice how a sufficiently large circulation area is provided, but note, also, that the "wash-down" action is retained — *perfect balance* is maintained. Then observe how the buoyant Bakelite ball floats in cement slurry, but instantly double-seals against rubber backed by Bakelite at the first reversal of pressure—either high or low. *Perfect balance* is maintained.

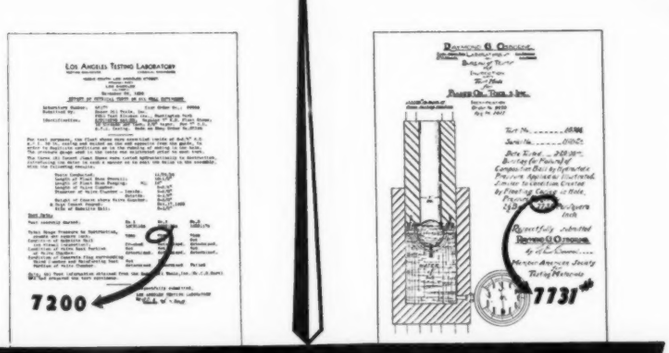
Consider next the Drillability of Baker Cement Equipment, and how *no metal ever is used*. The illustration (extreme left) pictures a half-section of the guide and plug made of Baker Formula Concrete and a minimum amount of Bakelite for the Valve—*perfect balance* is maintained. Both of these materials are easily and quickly *drilled out, drilled up* and *circulated out of the hole*. No metal or other fragments are left to prevent *immediate coring* or *safe, straight-hole* drilling. *Perfect balance* is maintained.



DRILLABILITY

And what about Strength? The reports of independent testing laboratories (where the conditions of running-in casing were duplicated) show strength of the Bakelite Ball, the Valve Seat and the Concrete Guide all to exceed 6,000 pounds per square inch. *Perfect balance* is maintained, and you always know that any "floating" unit of Baker Cement Equipment is stronger than the casing upon which it is run. Greater strength is unnecessary; less strength is hazardous —*perfect balance* is maintained.

Look on pages 169 (and following) for complete details, or ask us to send you the large Baker Catalog.



STRENGTH

Baker Cement Float Shoe, described on pages 169 to 173 of the 1936 Composite Catalog.

Baker Cement Float Collar — see page 174 of the 1936 Composite Catalog.

Here is the Ultimate in cementing efficiency—the Baker Cement Whirler Float Shoe—with side outlets which direct a portion of the cement upward with a "whirling" motion that insures complete distribution but eliminates danger of channeling.

BAKER OIL TOOLS, INC.

POST OFFICE BOX 71, HUNTINGTON PARK CALIFORNIA

COALINGA • TAFT • HOUSTON • OKLAHOMA CITY • TULSA • NEW YORK

BAKER CEMENT EQUIPMENT

MACHINERY and EQUIPMENT

Bradford Motor Works Offers New Working Valve

B-M-W Tex Type working valves for standard working barrels have been placed on the market by the Bradford Motor Works, Bradford, Pennsylvania, well-known manufacturers of high grade oil well supplies.

The makers claim that B-M-W Tex Type valves will pump more fluid than any other type of valve or pump. Actual tests, they state, show an increase of 5 percent to 13 percent over other types. The construction of the valve, with its many composition rings separated by metal washers, gives it an exceptionally long life even under bad sand conditions, they point out. Long runs are obtained, therefore, with these valves because of the ability of the special rings to withstand wear and the cutting action of the sand, it is stated. In effect, the plunger portion is a grooved seal plunger, made of rubber and fabric, readily adapting itself to the tube in which it works. It is claimed more fluid is pumped by this valve because there is no appreciable slippage, and because of the small frictional drag in the tube; it possesses the advantages of both cups and metal plungers without the disadvantages of either, the manufacturers say.

B-M-W Tex Type valves are made in three sizes—1¾ in., 2¼ in., and 2¾ in. for standard working barrels, and also 1½ in. and 2 in. for use in 2 in. and 2½ in. B-M-W Admore liner barrels, respectively. A circular published by the Bradford Motor Works giving complete information, including prices, will be sent upon request.

Development in Oxygen Metering

THE welding and cutting torch are tools of necessity in all branches of the metal-working industry today. The efficiency of these tools has been increased so immensely in the past few years that their application has become universal, and oxygen is used in relatively large volumes.

After two years of research, and with the coöperation of the laboratories of the largest producers of oxygen, American Meter Company, 60 East 42nd St., New York City, has announced the development of a meter especially adapted to the successful measurement of oxygen. This meter is their modern "Ironcase" in design, but the materials used in its construction are selected especially for this exacting service. As a result, these meters will successfully measure all the oxygen passing through the line, from the minimum rate of flow to the maximum capacity of the meters, the manufacturers state. They are available for low-pressure service, as well as for high pressures. Where used for measuring high-pressure oxygen they should be equipped with a volume and pressure gauge, a base pressure index, or a base volume index.

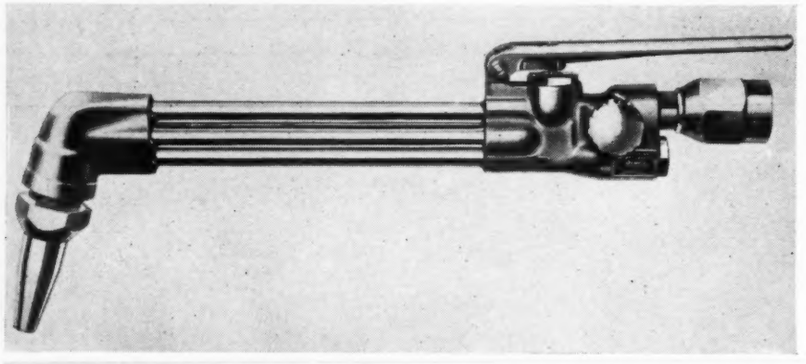
Ironcase Oxygen Meter With Case Removed to Show Operating Parts

Oxy-Acetylene Cutting Attachment

A NEW oxy-acetylene cutting attachment known as the Oxweld Type CW-22 has been announced by The Linde Air Products Company, 30 East 42nd Street, New York, New York. This new cutting attachment incorporates features of design and possesses a range and quality of performance that permit it to handle light sheet metal as well as all but the heaviest work at speeds and efficiency equal to those of the full size cutting blowpipe, it is stated. The attachment operates on low-pressure or medium-pressure acetylene, with equally satisfactory results. Severe field tests have proved its capacity, stability and endurance under all conditions, the manufacturers state.

The Type CW-22 cutting attachment can be used on either the Oxweld Type W-17 or W-22 welding blowpipe handle, thereby greatly extending the utility of these two popular blowpipes.

Sturdy, smooth operation at all times and all pressures is given by the new streamline injector and by the improved type cutting valve, with removable seat, centralized under the cutting lever. The mixed gas passage is formed by three Ambrac tubes. The length, and four 90-deg. changes of direction, afforded by this type of construction give exceptional flashback resistance. The body and head of the CW-22 are designed to combine strength and lightness, the body being of pressure-forged bronze while the head is a manganese bronze forging.



No. 37 Seismograph Drill

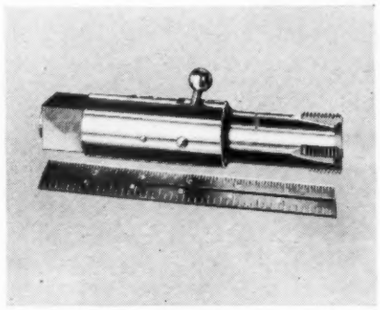
SULLIVAN Machinery Company announces the new No. 37 Seismograph drill, a motorized shot hole or core drilling rig expressly for oil exploration.

The No. 37 can be factory mounted on a short wheel base truck or can be supplied for field mounting on customer's truck, the manufacturers say. It can be supplied for power take-off drive from the truck engine or with separate power unit. Other features are the folding mast of welded tubular construction, the use of antifriction bearings throughout, the use of steel castings, the extreme convenience and flexibility of control, the ability to operate with hydraulic feed or feed off the line (Kelly rod), the makers point out.

Write for bulletin 90-B to Sullivan Machinery Company, Dept. 24, Michigan City, Indiana.

Landis Collapsible Hand Tap

AN improved hand sizing tap of the collapsible type has been added to the line of machine collapsible taps manufactured by the Landis Machine Company of Waynesboro, Pennsylvania. One of



these taps is illustrated in the accompanying photograph, showing a 1⅜-in. size, with an overall length of only six inches.

This tap, designed primarily as a hand sizing tap to take the place of the solid adjustable tap ordinarily used, offers the advantage of instant withdrawal from the work without requiring to be backed out, the manufacturers state. It also eliminates the tearing of the threads frequently caused by backing out a solid tap, as well as undue wear of the chasers, by having the radial clearance worn off in the backing out operation. Tapping time is, of course, saved, thereby increasing production, it is stated.

A small handle or trigger is on the side of the tap body for unlatching the tap and collapsing the chasers by pressing back on the handle. The chasers are reset by pressing against a plunger extending slightly beyond the rear of the tap shank. The tap shank is provided with a square end to fit a tap wrench. Any length of shank or tap can be supplied.

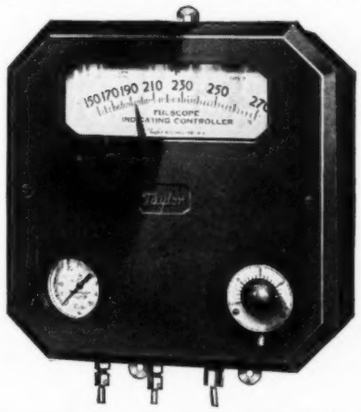
The tap is provided with a diametrical adjustment of approximately 1/32-in. both over and under the nominal chaser size, a total of 1/16 inch. The adjusting screw is in the front end of the tap and is of the ratchet type, making it self-locking to maintain size. A turn of one notch to the adjusting screw gives a diametrical movement of the chasers amounting to .001 inch. This feature makes the tap ideal for hand sizing work, it is pointed out.

The Landis collapsible hand tap can be supplied in all sizes from 1⅜ in. to 12 in., inclusive. Tap sizes and ranges conform with the regular machine collapsible taps manufactured by this company.

Taylor Fulscope Indicating Controllers

FOR the many processes where close throttling control is imperative but a record of the processing is not essential, the Taylor Instrument Companies, Rochester, New York, have put on the market a moderately-priced, high-adaptable, air-operated controller of the indicating type.

Many of the design and performance features of this new instrument previously have been available only in the Taylor Fulscope Recording Controllers; hence the name, Fulscope Indicating Controller. Practically every advantage of a custom-built instrument is possible



through the great diversity of optional construction features, the manufacturers state. But of even greater importance is the simplicity of the numerous adjustments by means of which the controller may be adapted to any changes in future processing requirements.

The outstanding features are as follows:

Either high-range or full-range sensitivity, as required. The former for processes having small time lags; the latter for time lags of any magnitude. Both are fully adjustable by turning a graduated dial.

The control point may be adjusted to any value within the control range. Direct-set feature is optional.

Controller action may be reversed quickly in the field by altering the position of a link.

Many standard control ranges to choose from within the limits of minus 100 and plus 1200 deg. fahr., or full vacuum and 3000 lb. pressure. Control ranges are interchangeable.

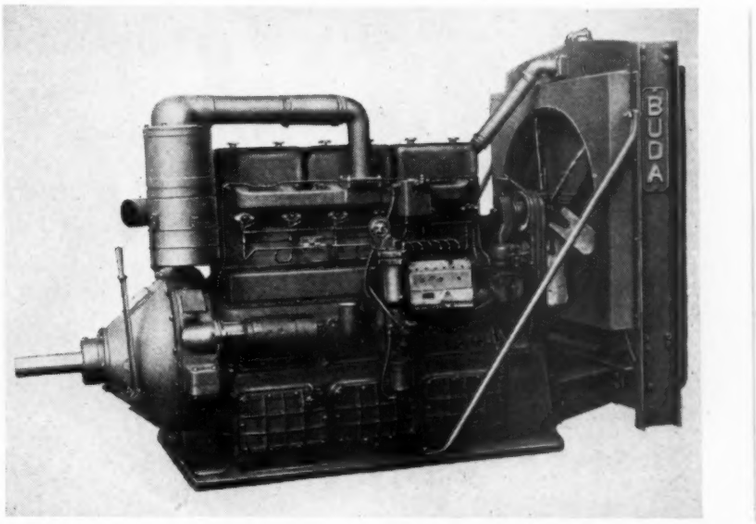
Temperature controllers may be equipped with mercury-, vapor-, or gas-actuated tube systems.

The large scale with bold numerals and graduations enable the operator to make accurate observations from a distance.

The smartly designed, black finished cast-aluminum case is available in both face and flush mounting styles.

Write for Catalog 86R.

Buda-Lanova Diesel Engine



THE Buda-Lanova Diesel engine, manufactured by The Buda Company, Harvey, Illinois, employs a very unusual type of cylinder head that results in "soft combustion" attained through increased turbulence and controlled combustion, state the manufacturers. This is accomplished principally by the use of an auxiliary air chamber that, because of its function, is called the "Energy Cell."

In the Buda-Lanova Diesel the rate of pressure rise is well within the limits of gasoline engine practice, it is stated; maximum pressures are not over 625 lb. per sq. inch. The compression ratio also is said to be comparable to that of a gasoline engine, being between 12.5 to 1 and 13.2 to 1. The unusual and controlled turbulance develops a high workable mean effective pressure, it is pointed out.

The Buda-Lanova Model 6-LD-909, illustrated herewith, is the most recent addition to the Buda line of industrial engines. The "909" is a 6-cyclinder, 4-cycle, solid injection engine with a 5¼ in. bore and 7 in. stroke, 909 cu. in. displacement, and develops 178 hp. at 1500 r.p.m., and 156 hp. at 1200 r.p.m.

The crankshaft is 3½ in. in diameter, is dynamically and statically balanced, has seven steel-backed main bearings of the precision type. The combined length of the main bearings is 18⅛ in., giving the crankshaft an unusual "riding surface." Connecting rods are 14¼ in. from center to center. Lubrication is force-feed to all main, connecting rod, and camshaft bearings. Connecting rods are rifle drilled for positive lubrication.

The Buda-Lanova Model 6-LD-909 augments the 6-LD-275, 6-LD-415, and 6-LD-468, which have incorporated the Lanova "Engery Cell" combustion system for some time. Very soon The Buda Company will announce the adaptation of the Lanova principle to all of its other large Diesels, it is stated.

Beltpaco Junior

A NEW transmission belt that fits into the field of light work has been announced by the New York Belting & Packing Company, Passaic, New Jersey. The new belt, named Beltpaco Junior, takes its place with the four other high grade transmission belts in the N. Y. B. &. P. line, namely: Test Special, Fortune, Beltpaco, and Great Seal Cord Endless.

Beltpaco Junior was particularly designed to take care of light or fractional hp. drives; transmission drives characterized by light tensions, small pulleys and small bearings; small machine or machine tool drives; auxiliary drives in machines. It is adapted also for use as shaping or forming belts in machines processing materials where its functions are like special light conveyors.

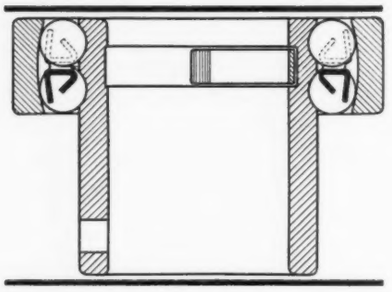
The designers of Beltpaco Junior have added extra plies to give this new belt "body" and, at the same time, they have retained a flexibility that allows the belt to hug small pulleys and be elastic enough to eliminate any danger of over-straining bearings, the manufacturers state.

The extra plies and narrow construction make Beltpaco Junior able to withstand machine overloads and to avoid fastener trouble; also make it rugged for shifting, it is claimed.

The SKF Grip-Lock Bearing

THE SKF Grip-lock bearing is the latest addition to the SKF line of anti-friction bearings, comprising in all more than 1200 sizes and types of ball and roller bearings.

The Grip-lock principle offers the advantage of quick, simple application of the bearing without the use of tools of any

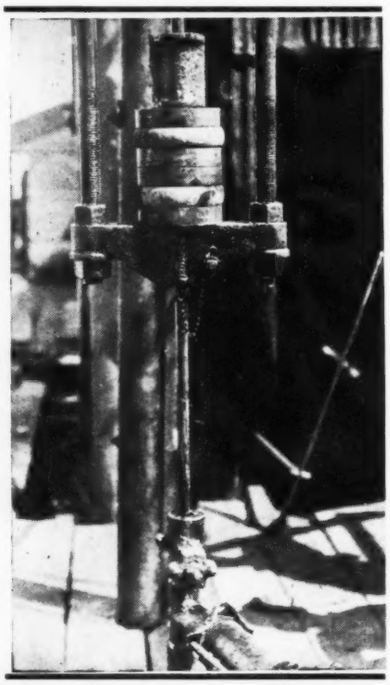


kind, and insures the user of a bearing positively locked to the shaft, the manufacturers state.

Essentially, the bearing is the conventional, well-known SKF self-aligning extended inner race bearing with an eccentric groove machined in the bore of the inner race. Fitted in the eccentric groove is a piece of spring steel known as the grip-lock shoe. When the shoe is in the deepest part of the eccentric groove the bearing may be readily slipped on the shaft. Then, by holding the inner race of the bearing while the shaft turns in the direction of operation, the knurling at the ends of the grip-lock shoe grips the shaft causing the shoe to wedge in the shallow part of the eccentric groove, thus securely locking the bearing on the shaft.

Teco Sucker Rod Shock Absorbers

THE Teco Sucker Rod Shock Absorber, manufactured by The Engineering Company, Tulsa, Oklahoma, under patent No. 2,038,527, is a rubber cushion inserted between the polished-rod clamp and beam-hanger carrier-bar of a pumping well in such a manner that the sucker rods "float" on rubber. According to the manufacturer,



dynamometer tests have proved that the e shock absorbers reduce the peak polished-rod load, or sucker rod stress, between 10 and 15 percent on the average well. Polished-rod horsepower, or energy input to sucker rods per barrel of fluid lifted, is reduced from 10 to 20 percent, it is stated.

Other advantages claimed are a reduction in difference between maximum and minimum loads, which is the fatigue producing load, increased lift efficiency, insulation of sucker rods from vibrations originating in surface equipment, gears, beam-hanger linkage, and from gas engine impulses.

The shock absorbers are supplied in three sizes having end-plate diameters of 6 in., 8 in. and 10 in. to fit various sizes of beam hangers, and for various operating conditions. Complete engineering data on the device will be supplied by the manufacturer on request.

"Smootharc" Welding Electrodes

A NEW line of coated rods for d. c. welding is being made and sold through the Harnischfeger Corporation of Milwaukee, Wisconsin, manufacturers of P&H-Hansen arc-welding equipment. The present lines includes five different types with both high and low rates of fluidity for various types of work in welding in flat, vertical, or overhead positions, and with ferrous and non-ferrous metals. Service tests show tensile strength of welds to be from 55,000 to 75,000 lb. per sq. in. with various types of rods ranging from $\frac{3}{32}$ in. to $\frac{3}{8}$ in. in size. "Smootharc" electrodes are designed primarily to speed up welding operations with a smoother, more easily handled arc and to reduce spatter losses, the manufacturers state.

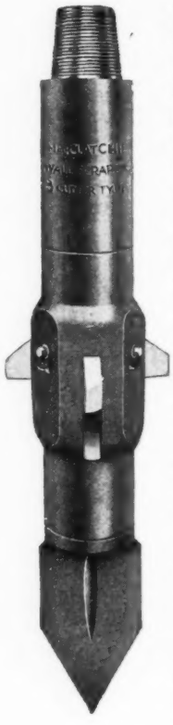
The new line is described in a new Bulletin (No. R-1), copies of which may be obtained upon request.

Goodrich No. 28 Aluminum One-Man Vulcanizer

THE Goodrich No. 28 Aluminum One-Man Vulcanizer, for vulcanizing splices in transmission or conveyor belting up to 28 inches wide, is a recent development of The B. F. Goodrich Company, Akron, Ohio. By the use of aluminum, cost of this unit has been greatly reduced and its weight lowered to less than 300 lb., which is said by the manufacturers to be 75 per cent lighter than similar vulcanizers of this size. Either of the two platens can be handled by one man or the entire vulcanizer lifted by two men.

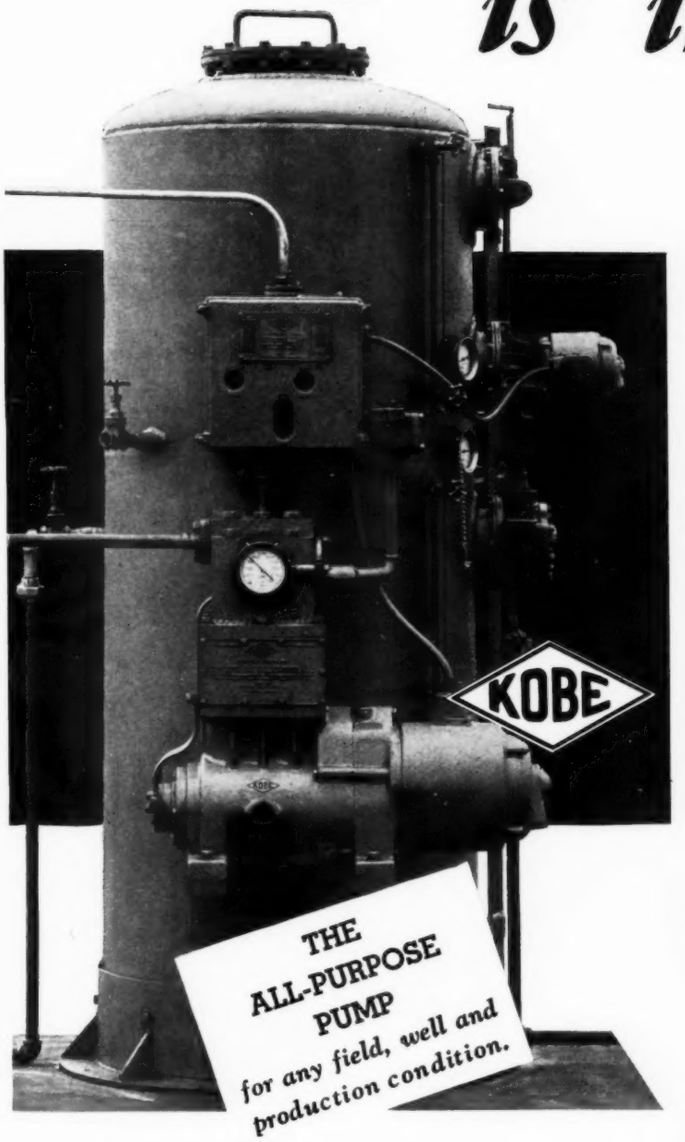
The Goodrich No. 28 Vulcanizer is said to equal the efficiency of any vulcanizer for transmission and conveyor belts up to 28 in. and offers the added advantage of being able to vulcanize narrow transmission belts up to 10 in., 6-ply inclusive, in one heat. The unit is available in 110 or 220 volts a.c. and d.c., 110 and 220 volts a.c., 110 or 220 volts a.c.-d.c. The d.c. types also may be used for a.c. of equal voltage by changing the plug-in connections on the side of the vulcanizer. The vulcanizer comes equipped with curing pad and galvanized sheet covers. No clamping bars are necessary.

MacClatchie Wall Scraper Gives a Message to the Derrick Floor



MACCLATCHIE Manufacturing Co., Compton, Calif., states that they have greatly improved the performance of their wall scraper in the past few weeks. According to the manufacturer, theirs is the only wall scraper that has practically closed circulation until the blades are sufficiently open where additional weight from the drill stem is certain to fully expand the blades. This feature enables the operator to know for a certainty when the blades are open. Drillers have accepted this readily as an essential advantage in a wall scraper, it is pointed out.

Safety *is important!*



Accidents always are costly, whether figured in time, money or man power. In designing the Kobe Pump, therefore, Kobe engineers gave careful consideration to the element of safety.

In order to reduce the hazard to an absolute minimum, all moving parts of the surface equipment are entirely enclosed, making it virtually impossible for the operator to sustain injury either as a result of accident or carelessness.

KOBE *hydraulic* PUMP

KOBE, INCORPORATED
(Pronounced KŌB)

Manufacturers of KOBE Heat-Treated Screen Casing and KOBE Pump

3040 EAST SLAUSON AVENUE **HUNTINGTON PARK, CALIFORNIA**

Brodie Quantrol

THE Brodie Quantrol is now available with a right-angled discharge outlet that can be faced either toward the left or right. According to the manufacturer, this unit simplifies piping arrangements on meterized tank-trucks.

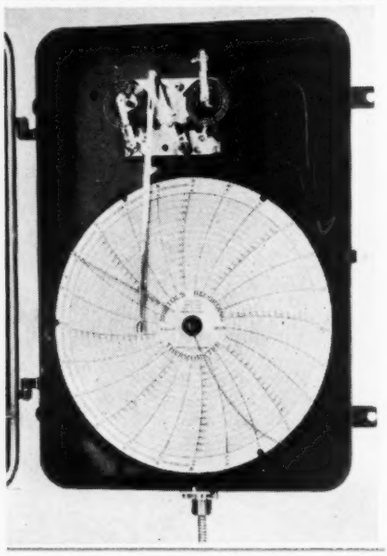
Other modifications of the Brodie Quantrol include: a printing counter that imprints delivery receipts in triplicate; it is also equipped with a direct reading vertical dial counter that can be faced in any direction.

The Quantrol is fully automatic in operation. It shuts-off after metering, recording, and discharging any predetermined number of gallons. It is widely used on tank-trucks and loading-racks for handling any petroleum product.

Illustrated booklets, fully describing the Brodie Quantrol may be obtained from Ralph N. Brodie Company, 971 61st Street, Oakland, California.

Bristol Designs a Small-Bulb Gas-Filled Thermometer

A GAS-FILLED recording thermometer, having a small temperature-sensitive bulb for long lengths of connecting tubing, has for many years been the dream of every instrument engineer. Such a thermometer, Bristol's Small-Bulb Gas-Filled Thermometer, now has been successfully developed, it is stated by the manufacturers. It is offered for measuring temperatures between —60 deg. fahr. and 1000 deg. fahr., where tubing lengths as long as 100 ft. and even longer under certain conditions, are required by the application.



This instrument has all the features of Bristol's gas-filled thermometers.

Bristol's Small-Bulb Gas-Filled Thermometer is fully compensated, being so designed that temperature changes in the case of the instrument and along the tubing are corrected for, independently, by means of an accurate compensating device. This device eliminates the necessity of long bulbs on thermometers having tubing lengths over 25 ft., it is stated.

The Small-Bulb Gas-Filled Thermometer consists of a rectangular case in which there are mounted two Class 111 measuring elements, connected through a compensating mechanism. Two capillary tubes, filled with the same gas, run from each element through one armor tube to the sensitive portion of the bulb. Only one capillary tube is connected to the temperature-sensitive bulb. The other is closed at the bulb end. Both capillary tubes, being adjacent, are subjected to the same temperature changes. Through the compensating mechanism, the tube and element not connected to the bulb correct for temperature changes along the connecting tube and in the case. In other words, the tube and element not connected to the bulb produce a balancing action that exactly offsets the effect of temperature variations along the tube and around the measuring element connected to the bulb, it is stated.

Lengths of tubing up to 100 ft. and even longer under certain conditions can be supplied with small size bulbs.

Small-Bulb Class 111 Thermometers are offered with one or two pens in the 12-in. chart size; and with one pen only in the 8-in. chart size.

Described in Catalog No. 1250, available on request to The Bristol Company, Waterbury, Connecticut.

Thermoid Rotary Hose

FOLLOWING two years of experimenting in the laboratory and in the field Thermoid engineers have developed a rotary hose that virtually doubles the usual bursting test pressure, according to the manufacturers.

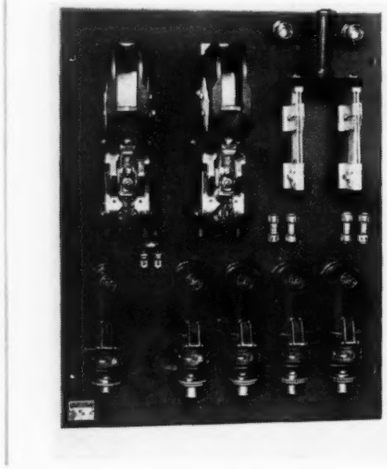
The principal improvement is the result of a specially designed automatic wire winder that applies wires to the hose at a carefully predetermined angle, assuring equal and proper tension on every wire and close uniform spacing, it is stated. The precision of the new Thermoid wire winder is comparable to that of a tool room thread cutting lathe.

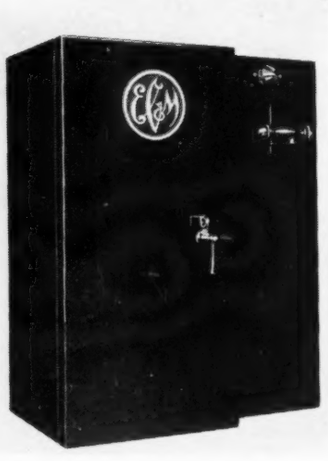
Exhaustive tests have shown that this new hose will stand up to 8000 or 10,000 lb. test burst pressure, the makers claim, and point out that reports on actual operation in the field have been uniformly excellent. Pieces of this new hose have withstood the drilling of from 14 to 20 wells without bursting, it is stated.

Further particulars can be obtained from the Thermoid Rubber Company, Trenton, New Jersey.

Protective Panel for Cranes

FOR use in protecting the electrical equipment used on electrically-operated cranes, of the overhead traveling, locomotive, and similar types, The Electric Controller & Manufacturing Company, 2721 East 79th Street, Cleveland, Ohio, announce a complete line of new Crane Protective Panels.





These protective panels are used in place of circuit breakers, knife switches, fuses, etc., which are otherwise necessary in the crane cab, and incorporate all of the necessary protective devices into a single, compact unit requiring a minimum amount of space, the manufacturers state. They are complete with main line contactors, knife switch, receptacles for pilot lights to show the operator when power to the crane is alive, an instantaneous overload relay in one side of the line, and an inverse time element overload relay in the opposite side of the line for each motor and a separately mounted push button for closing the contactors or resetting them after they have been tripped by an overload. Two single pole contactors are used for the main line and are closed in sequence; this method of operation providing the feature that both are free to trip and will open immediately if an overload exists while they are being closed or at any time the crane is being operated.

Protective panels are built in the open style or they can be completely-enclosed or front-enclosed. In all three styles, the main line knife switch is arranged for padlocking in the open position to prevent operation of the crane during idle periods or when repairs or adjustments to the crane are desired.

The accompanying illustration shows both the open type panel and the front-enclosed type with door and with externally-operated knife switch. These views show the construction of panels up to 160 hp., 230 volts. Beyond this rating, individual base construction mounted on angle iron frame is employed.

An installation of the LUFKIN TC-3-18 PUMPING UNIT on the Magnolia Petroleum Company lease in the Loma Novia Field, Texas. Hyatt Roller Bearings are important contributors to the correct design and dependable construction of this and similar units built by the Lufkin Foundry & Machine Company.

JUDGE THEIR MERIT *by their Performance!*

You'll make no mistake if you judge Hyatt Roller Bearings by the Companies that use them. Many of these Companies, over a long period of years, have found that the correct design, precision manufacture, and sound application engineering behind Hyatts mean smoother operation, longer life, and more dependable performance of Hyattized equipment.

If you have any bearing problem, in the machines you manufacture or in your own operating equipment, Hyatt plant and field forces are at your disposal. Hyatt Roller Bearing Company, Newark, Detroit, Chicago, Pittsburgh, San Francisco.

H Y A T T

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

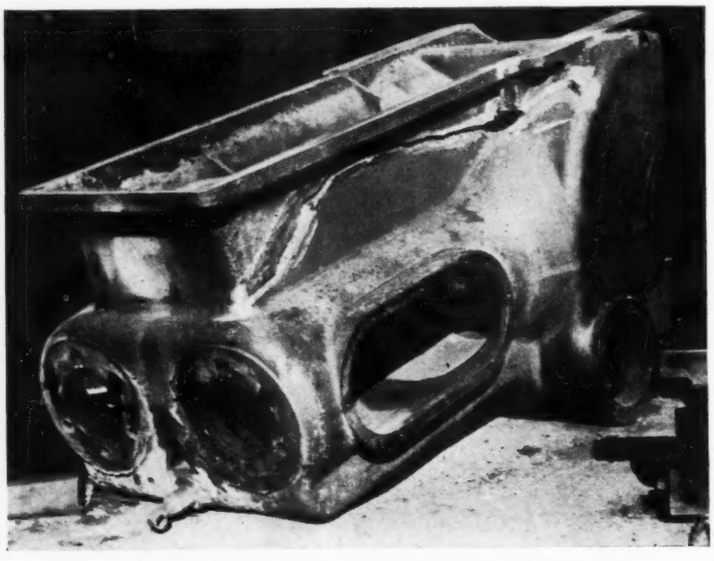
Repairing a Heavy Mud Pump Casting by Bronze Welding

MUD hogs, heavy duty pumps, used in the drilling of oil wells, pump mud and water at a pressure upwards of 500 lb. per sq. in. into the drill stem of the drilling equipment. They are large machines, sometimes measuring more than 7 ft. by 18 ft., and every oil well that is drilled requires the use of at least one or two such pumps. A single casting that is just a part of one of these pumps costs approximately $1200 and may weigh as much as two tons.

When a fractured casting from a mud hog pump was brought to a foreman of an oil well drilling company, he had it taken to the welding shop of an oil well supply company, who, in turn, called in an oxy-acetylene service operator for advice. The shop depended upon him when unusual problems were encountered.

The service operator knew from experience how such work should be handled. Once in Texas, he had saved $5,000 for the owners of five mud hogs that had been broken by a sudden freeze-up at night. He was therefore able to show how the bronze-welded repair of the casting in question could be done most easily. The drilling company authorized the job shop to go ahead.

The section of the casting that was broken weighed two tons. It was taken from the machinery end of the pumping unit. The part of the casting that was broken was from two to three in. in thickness and was cracked for a total distance of 13 feet. Besides this crack, a hole 12 in. in diameter had been broken out and the pieces lost.



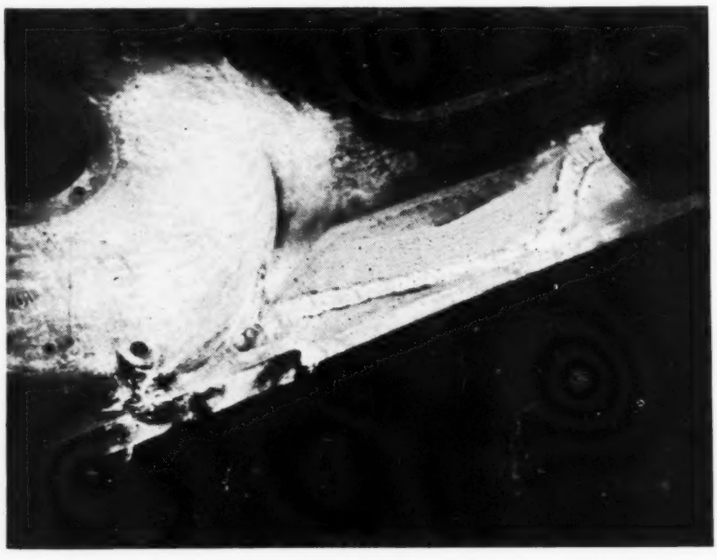
One of the cracks chipped out for an oxy-acetylene repair

The service operator gave instructions for preparing the casting and for preheating it. While this was being done, the service operator was able to obtain the necessary cast-iron pieces for patching from a foundry. A day was required for the preparation of the casting and another day for the bronze-welding.

Four natural gas torches were used for the preheating of the mud hog casting, which was started, in accordance with the service operator's directions, early in the morning. About three and one-half hours later the casting was ready for welding. Almost eight hours of continuous bronze-welding was required. The material obtained from the foundry was fitted as a patch into the 12-in. hole that had been broken out. Another piece of cast iron 8 in. by 18 in. and 2 in. thick was welded on as a web where the original web had been broken cut and lost. The finished repair appeared perfect. The job required 125 lb. of bronze welding rod.

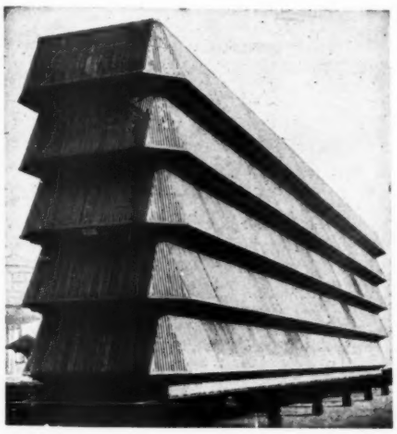
Among the oil field people much interest was shown in this work and many visitors were attracted. One of them announced that if the results of this job were satisfactory, he, too, would bring a casting to the shop to be welded.

The drilling company was very much satisfied with the bronze-welding of this casting and with the resultant saving of more than $1,000. Ten days later another type of mud hog pump was submitted for repair. This one was in far worse condition but was reclaimed as readily as the previous one.



Part of the completed mud hog repair that saved $1,300

More for Your Money



ABOVE *and* BELOW: *Two views of the same Marley deck type cooling tower—a modern roof installation for a large industrial plant.*

Only in Marley deck type cooling towers will you find *all* these attributes of higher cooling efficiency . . .

1. MARLEY *equalized spray distribution.*
2. MARLEY *controlled air flow.*
3. MARLEY *superior deck design.*
4. MARLEY *drift loss control.*
5. MARLEY *simplified design.*

CAREFUL BUYERS—write for full details.

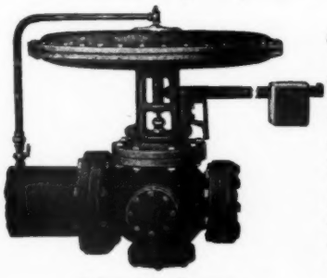
THE MARLEY COMPANY, 1915 Walnut, Kansas City, Mo.

MARLEY
DECK TYPE COOLING TOWERS

Equipped with Marley Patented Spray Nozzles

Marley nozzles lead the field in sales because they serve more efficiently and more economically in any type of water cooling system.

Valve Seats Renewed without Disturbing the Body of the Regulator



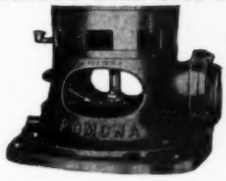
Fulton Low-Pressure Regulator

THE Fulton Low-Pressure Regulator can be fitted with new valve seats if desired, with the body of the regulator remaining undisturbed in the line. Plain directions will be mailed to any user on request. This regulator is capable of taking relatively high inlet pressures and reducing to the correct pressure for use. If the purpose is to deliver a very low pressure, the diaphragm surface is made very large so that the regulator becomes highly sensitive to any variation at the outlet and adjusts itself to compensate. Action is exact, positive and sure. Changes of pressure on the inlet side are therefore without effect on the delivered pressure. If gas supply should fail, automatic cut-off is provided. This regulator is easy to install, never sticks, gives unfailing satisfaction. One of a line of regulators, known and approved for fifty years, for all needs of gas control.

THE CHAPLIN-FULTON MFG. CO.
28-40 Penn Avenue Pittsburgh, Pa.

BUILT

FROM THE GROUND UP AND



DOWN

The strength of the sturdy oak is not all above the ground. The oak depends upon its roots for life and growth. So with Pomona Pumps. It's not what you see above the ground that alone makes Pomona a great pump. Of course, it's recognized that there isn't a sturdier, better engineered pump head built, but that's only the half of it. It's the assembly of shafting, bearings, impellers and bowls that are hidden from passing gaze that are Pomona's roots. Here lies the secret of Pomona's superior performance, long life and trouble-free operation. The high quality material, the meticulous machining, the precision fittings found in the bowl assembly of Pomona Pumps is seldom equalled—has never been excelled. You are PAYING for Pomona performance. Be sure your pump is Pomona—then you will GET IT.

Write for your copy of Pomona's new engineering circular on hydraulic laboratory pump testing.

POMONA PUMP CO.
53 W. Jackson Blvd., Chicago • 206 E. Commercial St., Pomona, Cal.

POMONA TURBINE PUMPS

Weldmaster Welding Torch

THE Modern Engineering Company, St. Louis, Missouri, makers of Meco oxy-acetylene welding equipment, are in production on their new Weldmaster ultra-light-weight welding torch. This torch with a standard tip weighs only 17½ ounces. A new alloy that can be forged, extruded and heat treated and has a tensile strength of mild steel is used in the construction. According to the makers the torch is perfectly balanced by the result of weight elimination and can be manipulated by the operator with maximum flexibility, and minimum effort. The circle mixer employed in all Meco torches has been improved and its capacity increased. Even the largest tips may be used efficiently with low gas pressures, as when working from acetylene generators, the manufacturers state. A new method of boring passages to rifle smoothness has been developed in this torch. Ideal flame characteristics under any operating circumstances in the full range of welding practice are claimed.

Other features of the Meco Weldmaster are: spring-tension equipped wheel handles that assure permanent adjustments even with rough handling and bumping of the torch. Wheel handles are fluted design and grip is thin with wide fluting. Grip is an electrically applied blue finish with balance of handle a contrasting silvery type alloy.

Weldmaster torches are made in two types: the Standard and the Super. A complete description and price is available from the manufacturers.

Timken Steel "Silmo"

THE Timken Steel and Tube Company has announced a new steel designated as "Silmo," especially designed for applications where an economical combination of high temperature strength and oxidation resistance is required. In the temperature range of 1000 deg.-1200 deg. fahr. "Silmo" steel has about twice the strength of carbon steel and its oxidation resistance compares favorably with that of 4-6 per cent Cr-Mo steel, according to the manufacturers. This new steel may be used to replace carbon steel where greater safety is required and as a substitute for the standard carbon molybdenum steel where oxidizing conditions are encountered, the makers state. Indicated uses for "Silmo" steel lie in the field of cracking furnace tubes, pipe still heater tubes, high pressure boiler and superheater tubes, and tubing used in the manufacture of air heating equipment.

Complete physical data on "Silmo" steel covering high temperature tensile properties, charpy value at elevated temperatures, heat embrittlement tests, creep strength, temperature-stress embrittlement tests, stability, and corrosion and oxidation resistance, together with curves showing the creep strength of "Silmo" steel at various temperatures and the relation between its creep strength and rate of creep at 800 deg., 1000 deg, and 1200 deg. fahr., are presented in a series of six looseleaf pages available on request to The Timken Steel and Tube Company, Canton, Ohio, or any of its branches.

Cleaning and Degreasing Fluid

A NEW cleaning and degreasing fluid has been announced by The Curran Corporation, Malden, Massachusetts, the makers.

"Gunk" a self emulsifying solvent has the valuable property of causing oil and water to mix perfectly. It does not form a mechanical mixture of oil and water but mineral oils and greases treated with "Gunk" form stable emulsions with cold water, the manufacturers state.

To remove grease and oil accretions, the makers state it is only necessary to treat with a solution of "Gunk" dissolved in kerosene or other low-cost solvent. After penetration the treated oils and greases may be removed by hosing with cold water as easily as you would rinse soap from your hands under the cold water faucet.

"Gunk" is harmless to paint and is rated as a "safety" solvent with respect to fire hazard, the manufacturers state.

Silver Anniversary Micromax Is Newly-Designed Model

THE "Silver Anniversary" Micromax recorder, latest and most serviceable of their long line of industrial recording machines, has been announced by Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania.

Marking the 25th year since this concern originated its recording potentiometer pyrometer, this Micromax not only provides in the one instrument all combinations of indicating, recording, signalling, and controlling, but provides these functions in ways unique to this model, the manufacturers state. Measurements are presented most conveniently; a bold scale and pointer shows the condition at the moment, and a clear record on ten visible inches of strip-chart shows it for the past several hours. On controllers, a second pointer shows control setting. Multi-point records may be in blue or in multi-color.

In this Micromax, control and signal contacts operate undisturbed by air currents when the door is opened, even when the chart is changed, or the pen refilled. Pen holds seven-week ink supply. An ingenious double frame makes all parts of the mechanism readily accessible, and enables the user to replace the chart without effect on other parts of the recorder.

Standard Micromax assemblies assure reliability for the vital operations of measuring, detecting, balancing, and control, the makers state. These assemblies have been improved wherever possible; contacts are heavier, and certain other component parts are new.

This machine and all other Micromax models are described in a new publication, Catalog N-33A, sent on request.

Geo. S. Mepham Corp. Announces Chemical "Z"

GEO. S. Mepham Corporation, manufacturers of Colox and Colox products, announces Chemical "Z" to the oil country trade. Chemical "Z," the latest addition to the line of Colox products, is described as a special chemical developed by the research department and the engineering staff of Colox Sales and Service for one specific purpose: better to control jell and viscosity in rotary drilling fluids. In a folder the qualities of Chemical "Z" in coping with the heaving shale problem and the cement-laden fluid problem are particularly treated due to the trouble previously existing for lack of a chemical other than commercial chemicals with which to treat drilling fluids. The literature sets out the fact that Chemical "Z" is not a commercial, that its use and application are restricted to the personnel of the Colox Engineering Department, and that dealers are not authorized to sell or dispose of Chemical "Z" without an order from a Colox engineer.

A copy of an attractive two-color folder is immediately available to operating men upon request to Colox Sales and Service, Shell Building, Houston, Texas, or to a Colox engineer anywhere.

Belted or Coupled Welding Generator

BASED on their newly-developed cross-field principle, a new welding generator for belted or coupled welding sets with a novel control system that is said to produce superior arc quality and eliminate rheostat, resistors, meter, reactor and exciter required in conventional designs, is announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. Due to its design the welding current is unaffected by the ordinary speed variations of the driving unit.

The new 200, 300 or 400 ampere generator with a new system of control allows the operator to adjust the generator to give the welding current required before the set is started, thus eliminating the trial and error methods ordinarily used, the makers state. This control of the welding current is accomplished by purely mechanical means that vary the armature reaction fluxes of the generator. This control is continuous, without steps, and permits minute changes in current adjustment. A polarity reversing switch is provided for instantly changing the polarity of the electrode as required by different electrodes, without changing the cable connections.

Elimination of the exciter makes it possible to use an exceptionally short and heavy shaft that greatly lessens possibility of vibration. The shaft runs on ball bearings that have a new and effective seal.

The generator is enclosed in a rugged shell of drip-proof construction with four solid machined feet. Two ball bearings are provided, one at either end. A drip cover over the commutator is removable to permit access to the brushes. The following tabulation gives pertinent specifications:

1 hour 50°C. rating in amperes	Current range in amperes	Speed r.p.m.	Approx. Net Wt.	Approx. dimensions Length	Width	Height
200	60-250	1500	800 lb.	36″	24″	23″
300	90-375	1500	1100 lb.	40″	24″	23″
400	120-500	1500	1500 lb.	39″	28″	26″

SHAFT EXTENSION—4 3/4″ long x 1 5/8″ d.a.
KEY - - - —3½″ x ⅜″ x ⅜″
ROTATION - —Counter Clockwise

Bridgeport Machine Company Leases New York Offices

The Bridgeport Machine Company, manufacturers and distributors of oil drilling, fishing, and production equipment, with headquarters at Wichita Kansas, has opened Eastern and export offices at 30 Rockefeller Plaza, with Ralph Hague in charge.

Hague has been with the company in various capacities for fifteen years in the Mid-Continent fields and is well known to oil producers.

Other executive offices of the company are maintained at Dallas, Houston, San Antonio, Tulsa, and Oklahoma City for close cooperation with many oil interests. Equal service facilities are now assured eastern and export buyers through the practical and intimate knowledge that Hague can supply in New York concerning both rotary and cable tool drilling.

An additional service now offered by the Bridgeport Machine Company is a semi-monthly bulletin covering all vital points of interest in the oil business, which will be mailed free to anyone connected with the oil business, upon request sent to the New York office.

Richard R. Bloss to Head International Derrick & Equipment Company, Beaumont, Texas

Richard R. Bloss

Announcement has been made that Richard R. Bloss, vice-president of International-Stacey Corporation, will take over the management of the International Derrick and Equipment Company at Beaumont, Texas, a subsidiary of International-Stacey.

Burwell Boykin, Jr., formerly in charge, is retiring from service but will continue his connection with the company as a member of the Board of Directors. The Beaumont division specializes in the design and construction of heavy rotary drilling equipment known to the trade as Boykin Greyhound Products.

Bloss has been connected with The International Derrick and Equipment Company of Columbus, Ohio, for 15 years and has a wide experience in the design and manufacture of oil country products. He has been to a large extent responsble for the development of the present line of Ideco products, which includes derricks, standard rigs, geared pumping machines, counterbalances, etc.

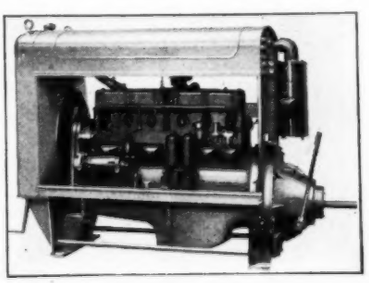
P. Charrin Returns to Houston

P. Charrin, general manager of the world-wide operations of the Schlumberger Well Surveying Corporation, has returned to the Houston, Texas, headquarters of the company after more than a week spent in inspecting the equipment and offices of the California division. It is understood that Charrin will relieve E. G. Leonardon, vice-president of the company in charge of domestic operations, while the latter is abroad.

with WAUKESHA power

This Hopper Servicing Hoist... driven by a 90-112 hp., six cylinder, Model DHKU Waukesha Oil Well Servicing Engine...mounted on an oil field truck...is cleaning wells in the "Weedpatch" field near Bakersfield, California.

Built to meet the demand for modern power units that will stand up under the severe conditions encountered in oil field service, Waukesha Oil Well Servicing Engines range in size from 40 hp. to 112 hp., and burn either gas or gasoline. Their design embodies many advanced features.



WRITE TODAY
FOR
BULLETIN 1019

WAUKESHA MOTOR COMPANY
WAUKESHA • WISCONSIN

WAUKESHA ENGINES

Eugene G. Leonardon to Europe

Eugene G. Leonardon, vice-president of the Schlumberger Well Surveying Corporation, left Houston, Texas, on June 12 for a business trip and vacation to Europe. During his visit abroad, Leonardon expects to spend part of his time at the headquarters of the Schlumberger organization in Paris, studying the new lines of activity of the parent company and the application of electrical logging methods in foreign fields.

Acting in Leonardon's capacity in Houston during the summer will be Paul Charrin, who was elected vice-president of the company at a recent meeting of the board of directors. Charrin, who has been connected with the Schlumberger organization for more than 11 years, is very familiar with the situation in the United States, having come here for the first time in 1926.

Bridgeport Machine Company Opening Rodessa Store

The Bridgeport Machine Company, with headquarters at Wichita, Kansas, is opening a branch store at Rodessa, Louisiana. A complete line of equipment used in the development of the territory is now in transit and the new store will be in a position to make deliveries and render services within a few days.

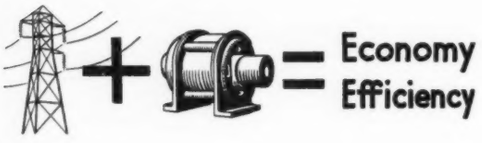
New and used sales and rental equipment will be carried and characteristic Bridgeport 24-hour service will be maintained. E. M. Johnson, who has been sales representative in the Pampa, Texas, territory, will have charge of the Rodessa store.

J. M. Loban, who has been in charge of the Bridgeport branch at Kilgore, Texas, has been transferred to Shreveport. Loban will have supervision of the Rodessa store, acting as a special sales representative in Shreveport and surrounding territory.

An Advertisement intended to sell a FACT!

It is not the purpose of this advertisement, or of any other advertisement over the signature of the Petroleum Electric Power Club, to SELL Purchased Electric Power.

But it is our constant aim to sell you a FACT—the fact that no two power problems are exactly alike in all their factors, which makes it eminently worth while to consider the hi-line and the electric motor in every case, with the co-operation of an engineer from your Power Company.



PETROLEUM ELECTRIC POWER CLUB

Bert R. Emrick Returns to United States

BERT R. EMRICK

Bert R. Emrick returned to the United States late in March from Burma. He has just completed 26 years continuous service there and in India with the Burmah Oil Company, Ltd. At the time of his retirement he was technical advisor for the company on drilling and production, a position of responsibility he has held for a number of years.

Emrick plans at present to make Oklahoma City, Oklahoma, his headquarters, and may become identified with the oil industry in the Mid-Continent as an independent operator.

Cyrus H. McCormick Passes Away

Cyrus H. McCormick, retired chairman of the board of directors of the International Harvester Company, died June 2 at his home, "Walden," in Lake Forest, Illinois, where he was stricken with a heart attack the previous Saturday.

Mr. McCormick was a principal factor in the formation of the International Harvester Company in 1902 and

CYRUS H. McCORMICK

its president from that time until 1918 when he became chairman of the board, which office he held until his retirement in September, 1935.

Cyrus H. McCormick was born in Washington, D. C., May 16, 1859, the eldest son of Cyrus Hall McCormick, inventor of the reaper, and Nancy Maria Fowler McCormick. He attended the Chicago public schools and entered Princeton University as a member of the class of 1879. Following college he entered the McCormick Harvesting Machine Company, of which his father was the head. The business career that long ago established McCormick as one of the world's foremost industrial leaders began with this association with his father. In 1884 the son succeeded to the presidency of the McCormick company.

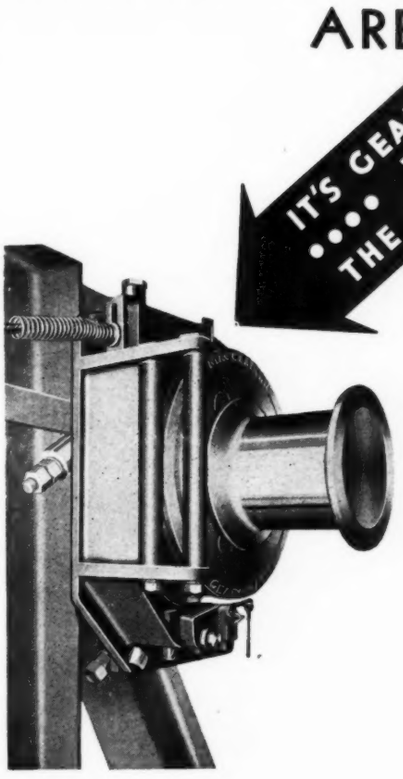
In 1902 the McCormick company united with others to form the International Harvester Company, and McCormick was elected the company's first president.

W. D. Shaffer Elected Mayor Brea, California

When W. D. Shaffer, head of the Shaffer Tool Works, Brea, California, returns home he will find a pleasant surprise awaiting him. While away on a trip to the Mid-Continent the City Council has unanimously elected him to complete the unexpired term of the former mayor, L. A. Hoghue, resigned.

This picture shows you

WHY MacCLATCHIE GEAROMATIC CATHEADS ARE BETTER



The Only Modern Cathead for Modern Deep Drilling and Tight Joints

Every superintendent, tool pusher, and roughneck using the MacClatchie Gearomatic Cathead says it is superior to any other joint breaking device they have ever used.

•

There is one outstanding reason why each MacClatchie Tool gives better service. This is one of a series of ads telling WHY.

It's geared 2 to 1. Double the power at half the speed permits running the line shaft slower, causing a slow, steady pull which breaks even the tightest tool joints easily — 8" joints included.

An absolutely positive kick-out permits the MacClatchie Gearomatic Cathead to make but one pull, eliminating any fouling and giving the utmost in safety.

There is no friction clutch nor costly bearings, hence lower maintenance cost. Simple lubrication is made possible through one Alemite nipple.

MacClatchie Mfg. Co.

COMPTON, CALIFORNIA — HOUSTON, TEXAS

Export: GEO. R. WOODS, 17 Battery Place, New York City

Paul Cavins Makes Tour of Gulf Coast, Mid-Continent, and Rocky Mountain Fields

Paul Cavins, president of the Cavins Company of Long Beach, California, has been making a tour of the Gulf Coast, and Mid-Continent fields in the interests of his company. While away he attended the International Petroleum Exposition at Tulsa, as well as the oil show at Houston.

Shortly after his return June 1st, Cavins started on a three weeks' trip to cover the Rocky Mountain fields, taking Mrs. Cavins, and their son, Paul, Jr., with him.

The Cavins Company manufactures the Cavins automatic suction bailer, fishing tool, and perforation washer and has distributing and service branches at a number of important points in the California, Texas, and Kansas fields.

Jay Taylor Promoted in the Halliburton Organization

Jay Taylor recently was promoted to general superintendent of the Halliburton Oil Well Cementing Company, Duncan, Oklahoma, a new post in that organization made necessary by continued growth and expanding activities.

For the past eight years he has been superintendent of the West Texas-New Mexico-Panhandle Division, with headquarters at Amarillo, Texas.

Previous to becoming superintendent he served his time as a truck driver and cementer since the Halliburton Oil Well Cementing Company was organized in June, 1924. Prior to that, he roughnecked on a drilling rig and attended Oklahoma University, taking a course in petroleum engineering.

JAY TAYLOR

Erle P. Halliburton is justly proud of the fact that he made it possible for Jay Taylor to go to college, advancing funds for this purpose.

His experience very aptly fits in for his new assignment.

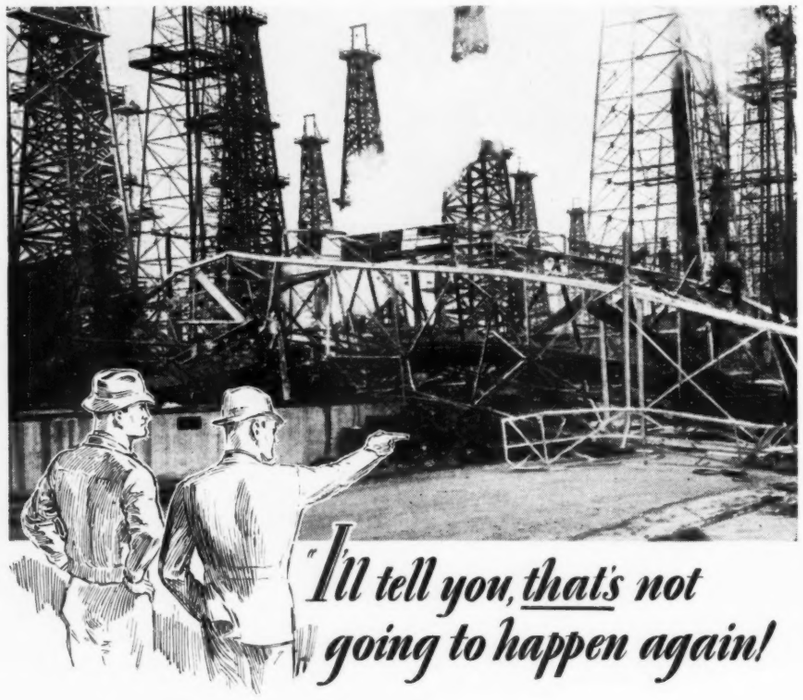
About eight years ago he married Imogene Herring of Amarillo, daughter of Colonel and Mrs. Herring, one of the best known families in the Texas Panhandle, being noted for their large ranch holdings and fine thoroughbred cattle, which have received many awards.

Mr. and Mrs. Taylor have two children.

DeLong Becomes Waukesha President; Fisher Vice-President

James E. DeLong, vice-president of the Waukesha Motor Company, who succeeded H. L. Horning as general manager, has been elected president, and James B. Fisher, chief engineer, vice-president. The presidency had been vacant since the death of H. L. Horning on January 4th last.

DeLong's association with the Waukesha Motor Company dates back 13 years to 1923 when he joined the company as field engineer in the development of the company's products for the oil industry. Fisher entered the engineering department as chief of design in 1914, and has been connected with the company since.



"I'll tell you, that's not going to happen again!

WE'RE not going to pull another well without a Weight Indicator. The Martin-Decker people make one especially for pulling rods and tubing; if we had one on that job we never would have pulled that derrick in." . . . . . He's right—neither he, nor you nor anyone else will pull a derrick in with a Martin-Decker "Quintuplex Toolpusher" Weight Indicator on the line, because the Weight Indicator tells you what the load is ALL THE TIME.

THE WEIGHT INDICATOR
MARTIN DECKER CORP.
LONG BEACH CALIFORNIA

San Joaquin Valley: A. F. McQUISTON, Oildale, California
Mid-Continent Distributor: REED ROLLER BIT COMPANY, Houston, Texas

C. R. Cox Promoted by National Tube Company

C. R. Cox, formerly general superintendent of the Ellwood Works of National Tube Company, recently was elected vice-president in charge of engineering and operations of the company, succeeding P. C. Patterson, who was associated with the National Tube Company for 49 years and who has been, since 1926, vice-president in charge of engineering and operations.

Patterson attended the University of Pittsburgh and entered the employ of the National Tube Works Company at McKeesport in 1886. He later became draftsman, foreman, and then superintendent of the lapweld department. In 1900 he was appointed chief engineer of the tube company, in 1922 assistant vice-president in charge of operations, and in 1926 was elected vice-president in charge of engineering and operations.

Cox was graduated from New York University in 1914, and in 1918 became identified with United States Shipping Board Emergency Fleet Corporation. In 1920 he entered the employ of Pittsburgh Crucible Steel Company at Midland, Pennsylvania, and in 1925 became superintendent, and in 1927 manager of Park Works of Crucible Steel. In 1930 he was appointed superintendent of the Babcock & Wilcox Tube Company plant at Beaver Falls, Pennsylvania. In 1934 he was appointed assistant general superintendent and in 1935 general superintendent of Ellwood Works of National Tube Company. Cox's office will be in Pittsburgh.

R. E. Watson Made Chief Engineer Lago Petroleum and Transport Co.

R. E. Watson, former division engineer for the Humble Oil and Refining Company at San Antonio, Texas, has accepted the appointment of chief engineer for the Lago Petroleum and Transport Company for service in Venezuela.

On June 6th, at Waco, Watson married Miss Elizabeth Colgin, leaving immediately after the wedding for New York, and sailing for Maracaibo the 12th.

Lee Webster, Jimmy Posgate, Hulin Kemp, John Bell, Paul Turnbull, and Jon Long sponsored the groom.

Grove Universal Regulator Described

An interesting new bulletin describing the Grove Universal Regulator has been published recently. It explains in detail the operating principles of this regulator. Many sectionalized drawings, as well as installation views, make this bulletin of value to producing and pipe line engineers.

The Grove regulator design is said by the manufacturers to be as remarkable as its performance on all pressures. It is especially built for pressures as high as 3500 lb. per sq. inch. Single-stage pressure reductions from 3200 lb. to 350 lb. are now in actual operation, it is stated. According to the manufacturers, it operates equally well on oil and gas, or on both at the same time.

The Grove Universal Regulator is compact and is made with a forged steel body. Due to careful internal design, its valve and valve seat are not subject to rapid erosion even though mixtures of sand, gas, and oil flow through it under high pressure, the makers say.

The new bulletin may be procured by writing the Grove Regulator Company, 1072 Bryant Street, San Francisco, California.

Users of Green Head Line Scales agree with Mr. Reneau, because Green Head tells *exactly* the load on the line at all times. No fluid to leak. Not affected by temperature variations.

Distributed by

GREEN HEAD

BIT AND SUPPLY CO.

Oklahoma City, Okla.
Scott, Louisiana
Houston, Texas
Odessa, Texas

Pomona Pump Maintains Hydraulic Test Laboratory

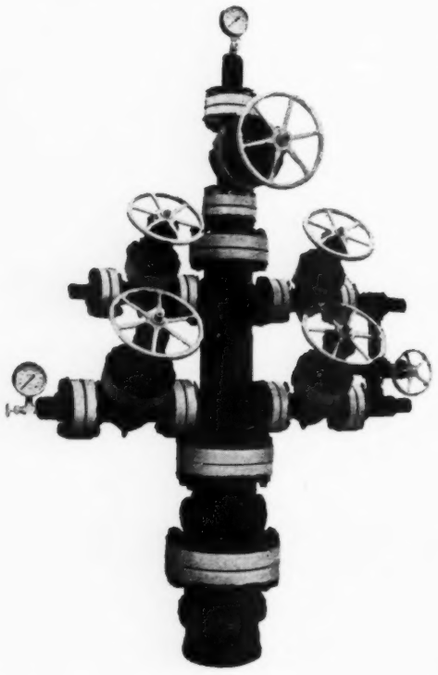
Purchasers of Pomona deep-well turbine pumps often remark about the closeness with which actual performance records agree with statements of efficiency, says W. H. Day, vice-president in charge of sales. The reason for this is that Pomona maintains a complete research department in a special building set apart for pre-study and final test of its products. Many devices have been designed exclusively for use in making accurate readings of performance as to speed, b.hp. input, pressure head, and water flow.

To make these observations parallel those of actual operation in the field as closely as possible, the research laboratory is provided with a concrete well 135 ft. deep and 4½ ft. in diameter. Here Pomona pumps are tested at variable speeds from 500 r.p.m. to 3500 r.p.m., with records obtained on integrating and automatic reading tachometers. Brake horsepower input is measured by a specially built vertical dynamometer, and driving torque is indicated by a stationary precision weighing apparatus that is accurate to 0.01 horsepower. Power input to the motor is measured by a calibrated watt hour meter, and the overall efficiency and power factor of the motor are readily determined in advance of shipment.

Pressure head measurements are made by a specially-constructed mercury column, reading direct both above and below a permanently fixed bench mark or datum line. Heads can be measured up to 320 ft. with an accuracy of 0.01 ft., it is stated. Water flow calculations are taken from calibrated rectangular weirs of large capacity and very low approach velocity, through volumetrically calibrated venturi meters. Quantity flows up to 25,000 gal. per min. are measured on a finely divided vertical scale with a vernier gauge reading to 0.0005 feet. Many other important facts, such as column friction head losses and shaft bearing losses with different types of column construction, are regularly obtained. This information is available to the purchaser in advance, and permits accurate budgeting of actual operating costs, the manufacturers state.

The Pomona Pump Company has issued a bulletin, copies of which may be obtained by addressing the company at Pomona, California, or its branch office at 53 West Jackson Boulevard, Chicago, Ill.

This modern plant, with 16,000 square feet of floor space, was built to meet the ever growing demand for O-C-T Streamline Christmas-trees and other Well Control Equipment.



The new home of O-C-T products stands as a testimonial to the success of equipment we have designed to better fill your needs in the oil country. To us it symbolizes the happy cycle of "Better equipment enables you to operate more safely and economically, and your better patronage in turn enables us to provide this better means of serving you."

We invite you to visit this new plant and to see for yourself the care taken in producing O-C-T products.

OIL CENTER TOOL CO.
QUALITY O-C-T PRODUCTS
HOUSTON, TEXAS, U.S.A.
CABLE ADDRESS "OCENTOL"

Selling Through Supply Stores

Five Years Without Lost Time Accident

The D + B Division of the Emsco Derrick and Equipment Company, of Los Angeles, California, recently celebrated their fifth consecutive year without a lost time accident. This period represented a total of 720,009 working hours, and credit for this remarkable record is given to the fine work done by the Shop Safety Committee, as well as to the coöperation of the employees as a group.

During the meeting held at the plant in honor of the occasion, J. S. A. Smith, secretary and treasurer of the organization, in a very interesting talk, complimented those responsible for this exceptional safety record and urged all employees to carry on the good work and remain permanently safety minded.

A. F. Macdonald, of the New Amsterdam Casualty Company, also addressed the gathering.

Death Claims J. W. Reeser

Joseph Warren Reeser, 66 years old, of Huntington, West Virginia, superintendent of distribution for the United Fuel Gas Company, died at his home recently. His death was not unexpected, as he had been in ill health for the last year. Reeser enjoyed a wide acquaintance in the natural gas industry.

T. N. St. Hill Making Extensive Trip

T. N. St. Hill, vice-president of Petroleum Rectifying Company of California, who recently returned to his offices in Los Angeles from an extensive tour through the Gulf Coast, Mid-Continent, and Central States, is making another trip to various points throughout Texas where he will inspect a number of Petreco Electromatic De-Salting Plants installed during the past year. While away, St. Hill will spend several days in El Paso and Houston, Texas, and may decide to inspect other similar plants operating at points as far north as Wisconsin. He expects to return to Los Angeles about the end of June.

Buda Engine and Equipment Company Organized

The Buda Company of Harvey, Illinois, for many years builders of heavy-duty multiple-cylinder oil field power units, has anounced the organization of Buda Engine and Equipment Company, with headquarters at 1003 Shell Building, Houston, Texas. A warehouse and shop also are in Houston. A complete stock of Buda oil field power units and necessary accessories will be carried at all times. An up-to-date store also has been opened in Kilgore.

The addition of these outlets at Houston and Kilgore gives The Buda Company complete and uniform oil field distribution and service throughout the United States. A complete stock of repair parts is carried by The Jno. Muller Company at Fort Worth, Houston, Kilgore, and Odessa. Other branches are Buda Engine Service of Tulsa at Tulsa, and Production Equipment Company at Los Angeles.

Buda Engine and Equipment Company will be in charge of A. R. (Al) Flournoy and W. H. (Bill) Benduhn. Each has an intimate knowledge of oil field operating practices and power recommendations, and has been trained thoroughly in multiple-cylinder engines.

Westinghouse Appoints Engineering Manager

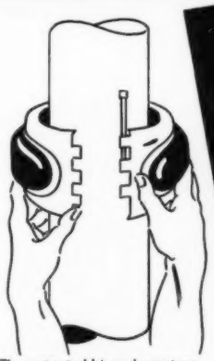
Appointment of M. W. Smith as manager of engineering is announced by Dr. S. M. Kintner, vice-president of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

Smith has been associated with Westinghouse since 1915. Then a recent graduate of Texas A. & M. College, he joined the company as a student engineer and has since been continuously identified with generator engineering operations, first as design engineer, later as a section engineer, and more recently in charge of the design of the large rotating alternating current machinery of the generator division.

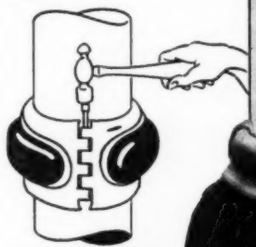
He will maintain his new office at the Westinghouse East Pittsburgh headquarters.

EASY TO INSTALL

GRIZZLY DRILL PIPE PROTECTORS



The patented hinged construction makes it simple and easy to place on the pipe. No special tools of any kind required.



When in position on pipe simply drive the tapered locking key through the tapered slots with a light hammer.

To remove, tap the tapered locking key upward through tapered slots until loose, and pull out

The PROTECTOR that PROTECTS

Just as EASY TO TAKE OFF

They're easy to install and easy to take off, BUT—once locked on the pipe they stay put and will withstand any blow or strain encountered in service without slipping, piling-up, or overlapping. Cannot snap off or tear off.

E. M. SMITH COMPANY
600-650 South Clarence St., Los Angeles, California
Sold in the Mid-Continent and Gulf Coast by Continental Supply Co., T. T. Word Supply Co., Inc., Houston, Texas — In All Their Stores and Independent Pipe & Supply Co., 2311 West Street, Houston, Texas. Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York City

Discussion of Petroleum Problems to Form Important Part of A. S. M. E. Meeting

At the semi-annual meeting of The American Society of Mechanical Engineers, to be held in Dallas, Texas, June 15 to 20, in addition to general sessions and sessions on transportation, power, process industry, machinery, and hydraulics, there will be a number of petroleum sessions dealing with problems under the following headings:

Equipment problems in handling oil as a locomotive fuel.

Railroad lubricants.

Railroad fuel oil.

Diesel electric locomotives for switching and transfer service.

Cementing hot oil wells.

Plunger lift for producing deep wells.

New Methods in oil field production.

Heat transfer and pressure drop in shell and tube.

A.S.M.E.-A.P.I. unfired pressure vessel code.

Corrosion of pipe lines.

Operating cost of totally electrified pipe lines.

Steam drilling equipment.

Wire line coring.

Design of Diesel electric oil well drilling units.

High speed gas engines for pumping.

High speed Diesel engines for drilling.

This is the first time that the A.S.M.E. has held a convention in the Southwest, and while the complete program covers 50 different papers, the sessions dealing with petroleum problems will be most interesting to oil men in the Mid-Continent field, and a very large attendance of oil men is expected for these meetings.

While the technical sessions are from June 17th to 19th, inclusive, the convention really starts on June 16. A special train from the North will arrive the morning of the 16th.

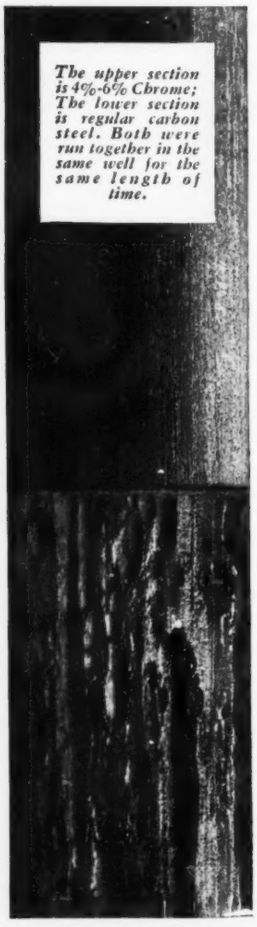
June 20 is "Engineers' Day" at the Texas Centennial, and engineers of all branches of the profession are expected to take part in this big event. Principal speaker at the Centennial exercises will be Dean A. A. Potter of the engineering school of Purdue University, who is president of the American Engineering Council, Washington, D. C. President Potter's paper will be, "The Engineer and Public Welfare."

H. G. Trimble With Muskogee Iron Works

H. G. Trimble recently was added to the sales staff of the Muskogee Iron Works of Muskogee, Oklahoma. That company has opened an office in the Thompson Building in Tulsa and Trimble is in charge, representing them

H. G. TRIMBLE

in a sales capacity. He has been connected with the oil and gas industry since the early days of the Illinois field where he was with Treat and Crawford, producers. He has an extensive acquaintance throughout the oil country.


The upper section is 4%-6% Chrome; The lower section is regular carbon steel. Both were run together in the same well for the same length of time.

Corrosion Resistance **PLUS!**

FLUID PACKED PUMP

Lasts FOUR Times Longer And Still GOING STRONG!

Corrosive conditions in this major operator's well were so severe that the average pump lasted only 30 days. On November 16, 1935, the operator installed a FLUID PACKED PUMP with Tube Assemblies made of 4%-6% Chrome. At this writing, April 5, 1936, more than 4 months later, this Fluid Packed Pump is still in the well, efficiently pumping 365 barrels of fluid daily. The record shows NO DOWN TIME for pump repairs, though the pump has given FOUR TIMES THE SERVICE!

Study This Unretouched Photo

This unretouched photograph shows how Fluid Packed Pump Tubes, with a 4% to 6% Chromium content, resist corrosion. The upper section is 4% to 6% Chrome; the lower section is regular carbon steel. Both were run together in the same well for the same length of time.

By introducing this amount of Chromium, we are able to secure corrosion resistance; to offer maximum wearing and abrasive resistant qualities; and to hold the selling price at a sensible figure.

"NO DOWN TIME"

is a common notation on FLUID PACKED PUMP field performance records, regardless of the adverse conditions under which they are operating.

See the Fluid Packed Pump Section in your 1936 Composite Catalog—or write for complete information.

FLUID PACKED PUMP CO.

BOX 64 • LOS NIETOS, CALIFORNIA • U.S.A.

Mid-Continent and Texas Distribution

FLUID PACKED PUMP CO.—MID-CONTINENT

2 S. E. 29th ST., OKLAHOMA CITY, OKLAHOMA

Gulf Coast Headquarters: **409 Velasco St., Houston, Texas**

A MODERN PUMP FOR MODERN CONDITIONS

Protected by Patents No. 1545474, 1545475, 1549175, 1621046; others pending.

TRADE LITERATURE

VERTICAL PUMPING ENGINE—"Cooper-Bessemer announces the Type G-SD," is the title of a four-page folder distributed at the International Petroleum Exposition. Extra copies of this folder are now available. The folder lists "12 field-proved features of this 40-horse engine"; shows hp. curves, cross sections, and shop views of the operating and exhaust sides; a table of general data is included.

The Cooper-Bessemer Corporation is offering the G-SD folder to "those who are interested in slow-speed reliability in a high-speed engine space." Requests may be addressed to the plants at Mt. Vernon, Ohio, Grove City, Pennsylvania, or to any of the Cooper-Bessemer district offices.

OIL WELL MANUFACTURING CORPORATION, Los Angeles, announces publication of Bulletin No. 111 illustrating and describing Red Devil Dia-Hard steel slush pump liners. Copies may be had by writing the manufacturer at 6000 South Alameda Street, Los Angeles, California.

A BOOKLET ENTITLED "Instruments from the Executive Viewpoint" has been issued by the Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, Pennsylvania. It illustrates and describes briefly the part instruments and controls play in the modern industrial plant. Those writing to the company will receive a copy of the booklet free.

COMPANY ENGINEERS interested in Aerator type cooling towers will find much valuable information in a new bulletin released by The Fluor Corporation, Ltd., Los Angeles, California.

This bulletin contains illustrations, descriptive matter, and engineering data on the Aerator type tower. It is said to be particularly helpful to engineers in determining the size tower required for their needs. All engineering data has been assembled during the past several years from authentic operating records of Fluor towers installed in all parts of the world.

The bulletin shows views of both the standard type and coil type towers, together with diagrams of actual operations. Charts showing performance factors also are reproduced. In addition, there is shown a blueprint detailing installation method of Fluor Aerators on existing louvre towers.

Those interested in obtaining a copy write The Fluor Corporation, Ltd., 909 East 59th Street, Los Angeles, California, and ask for Bulletin T-236.

THE TITUSVILLE IRON WORKS COMPANY, Titusville, Pennsylvania, has issued a bulletin on the Titusville master tank heater. This heater embodies several new features in the construction of suction tank heaters. The back end of the heater consists of a valve of the same diameter as the heater shell, which is operated on the front head of the heater, and when closed permits removal of the heating coil without disturbing the contents of the tank into which the heater is placed, or without risk of loss of the contents of the tank.

BAROCO, AN ECONOMICAL salt water-resisting drilling clay, and Fibrotex, effective material for preventing or regaining lost circulation in drilling wells, are described in two new bulletins published by the Baroid Sales Company. Copies may be obtained from the company at Los Angeles, California; Houston, Texas, and Tulsa, Oklahoma.

***The* answers *to the* 5 questions**
most engineers ask . . . . . about
COOK'S GRAPHITIC IRON PISTON RINGS

WHAT COOK'S GRAPHITIC IRON IS

A refined cast iron free of all steel-like inclusions and other abrasive matter and permeated with excess carbon in the form of graphite flakes. Its Brinell hardness provides a favorable differential between ring and cylinder.

AVAILABLE ONLY IN COOK'S RINGS

You can get COOK'S GRAPHITIC IRON only in COOK'S Rings, made in all conventional styles and in special designs including COOKTITE Sealing Rings, Oil Control Rings and Sectional Compressor Rings.

ECONOMIES FROM COOK'S RINGS

Comparative operating data show that when COOK'S Rings replace ordinary rings, cylinder wear is retarded, ring replacements and shutdowns for repairs are fewer, and engine life is prolonged.

WHERE COOK'S RINGS EXCEL

Where superior wearing properties are needed to meet conditions of poor lubrication, extreme pressures and high temperatures, COOK'S Rings get the call. They're the accepted standard in the Petroleum Industry for Natural Gas Pumping engines, Gasoline Extraction units and Oil Pipe Line engines. They're working successfully in Steam Engines operating under a total pressure of 1840 pounds at 797° F. total temperature. They predominate in Diesel Trade because they increase cylinder life as much as 50%. In Ammonia Compressors and similar services where lubrication is a problem, COOK'S Rings have repeatedly proved they have longer life.

HOW TO ORDER COOK'S RINGS

Since COOK'S Rings fit existing grooves, the usual information only is required to fill your order. Make sure of getting the genuine by specifying COOK'S Rings on your replacement requisitions or on orders for new engines. Send emergency orders direct to our home office. Write today for the complete story on COOK'S Rings.

C. LEE COOK MANUFACTURING CO.
INCORPORATED
New York Cleveland Baltimore Los Angeles LOUISVILLE, KY. Chicago Tulsa San Francisco New Orleans

CLEANED OUT

WITH THE . CAVINS

The above well was cleaned out with the Cavins Automatic Hydraulic Suction Bailer in about one-third the time it would have taken to do the job with a spudding-type bailer. Note the amount of sand recovered. The Cavins does a better job of cleaning out, and does it faster, easier, and more economically. Write for descriptive Bulletin No. 36.

THE CAVINS COMPANY

2853 Cherry Avenue—Phone 414-14 Long Beach, California

Cable Address: "Cavins, Long Beach" *Foreign Representative:* R. J. Eiche

Bakersfield, Calif., 3800 Chester Ave., Phone 1779-J; Taft, Calif., 200 Center Street, Phone 78; Ventura, Calif., Phone 4008; Honston, Texas, Cavins Bailer Service, P. O. Box 4174, Phone Wayside 1451; Kilgore, Texas, Cavins Bailer Service, P. O. Box 1325, Phone 753; Pampa, Texas, Cavins Clean Out System, P. O. Box 151, Phone 1220; Oklahoma City, Okla., Cavins Clean-Out Service, P. O. Box 1093, Phone 3-6441; Wichita, Kansas, Cavins Clean Out Service, 3226 East Pine, Phone 45-449; Lyons, Kansas, care Carson Machine & Supply Co., Phone 227

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3 Years - - 2.00	2 Years - - 3.00

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The Petroleum Engineer
P. O. Box 1589
Dallas, Texas

Pittsburgh Meeting of A.P.I.

The Eastern District of the American Petroleum Institute held its annual meeting in Pittsurgh, Pennsylvania, June 4 and 5. One of the principal speakers was Axtell J. Byles, president of the Institute, who discussed "Production and the Compact."

The program opened Thursday morning, June 4, with S. W. Meals, president of Carnegie Natural Gas Company, Pittsburgh, presiding. The address of welcome was delivered by Mayor W. N. McNair, of Pittsburgh. Frank M. Brewster, president of Belmont Quadrangle Drilling Corporation, Bradford, Pennsylvania, presented a paper on "Drilling in Gas Wells Under High Pressure."

The second paper on the morning program, "Deep Well Drilling Problems and Their Solution," was presented by K. C. Heald, chief geologist of Gulf Oil Corporation, Pittsburgh.

George Wittmer, III, of Wittmer Oil and Gas Company, Pittsburgh, presided at the Thursday afternoon session.

T. W. Phillips, Jr., president of T. W. Phillips Gas and Oil Co., Butler, Pa., presented a paper, "Taxation and Oil Production." Another paper, "Hopeful Present Day Signs for Eastern Oil and Gas Production," was delivered by President P. H. Curry of South Penn Oil Co., Pittsburgh.

J. C. Askam, of The Ohio Oil Company, Findlay, Ohio, presided at the morning session Friday. N. M. Wilder, Kentucky Department of Mines and Minerals, Lexington, presented a paper: "Repressuring Limestone Producing Areas in Kentucky." The session was closed with the presentation of a paper: "Gas Measurements," by Vice-President Thomas R. Weymouth, of Columbus Gas and Electric Co., Pittsburgh.

J. H. Newlon, superintendent of production for the Equitable Gas Company, Pittsburgh, presided at the Friday afternoon session. The first paper, "Production and Production Problems in Michigan," was presented by W. M. Peck, of The Pure Oil Company, Saginaw, Michigan. A paper, "Petroleum Geology of Ohio," also was presented by State Geologist Wilber Stout, of the Geological Survey of Ohio, Columbus.

The following officers were elected: J. C. Askam, of the Ohio Oil Company, Findlay, Ohio, chairman; F. E. Eckert, Bradford, Pennsylvania, George Wittmer, Pittsburgh, Fred Benkert, Pittsburgh, G. L. Hassler, Pennsylvania State College, and J. J. Schmidt, Cleveland, all vice chairmen; and Christy Payne, Jr., Pittsburgh, secretary-treasurer. H. H. Phillips, retiring chairman, was made chairman of the advisory committee.

Preparation of Solvent Naphthas from East Texas Heavy Naphtha

By GEORGE M. WOODS

DEVELOPMENTS during the past few years in the field of lacquers and varnishes have shown a decided trend toward the use of synthetic resins. The development of these synthetic resins, soluble only in the more aromatic hydrocarbon solvents such as toluene, xylene, and so forth have created demands on petroleum refiners to improve the solvency (aromaticity) of their products. Catalytic high-pressure hydrogenation of naphthenic type petroleum fractions has been shown to be a suitable method for preparing suitable solvent naphthas by Sweeney and Tilton[1]. However, hydrogenation is not available to all refiners because of controlled patents, hence other refiners are being forced either to give up this profitable business or devise other methods of producing solvent naphthas with high solvency powers.

A careful study of the Sweeney and Tilton article[1] indicates that the solvent naphthas that they produce by hydrogenation are highly aromatic. It has long been known that solvents such as liquid sulphur dioxide could be used for the removal of the aromatic compounds from kerosene and gasoline. The possibility of producing these paint and lacquer solvents by liquid sulphur dioxide treating of a suitable naphtha-kerosene cut that contains appreciable quantities of aromatics, was hence undertaken in the laboratory.

Inspection data on hydrogenated solvent naphthas as given by Sweeney and Tilton in their article is given in Table I. East Texas straight-run heavy naphtha was chosen as the most suitable source of these aromatic solvent naphthas because of its easy availability and large natural supply.

The sample of East Texas heavy naphtha used in these experiments represented the 12 to 35 percent cut from East Texas crude. Inspection data on this cut is given in Table II, column 1. This cut of heavy naphtha was given a 150 per cent by volume batch treat of liquid sulphur dioxide at —20 deg. fahrenheit. Two layers resulted, and after separation the sulphur dioxide was allowed to evaporate off, leaving the naphtha portions behind. These layers were caustic-washed and measured. Inspection data on the two washed layers are shown in Table II, columns 2 and 3. The washed bottom layer was steam-distilled into overhead cuts in a well-lagged laboratory fractionating column. Attempts were made to blend for cuts of the following boiling ranges:

Cut number 1 200° F. initial, 275° F. final.
Cut number 2 275° F. initial, 365° F. final.
Cut number 3 365° F. initial, 419° F. final.
Cut number 4 419° F. initial, 460° F. final.

It will be noticed that these boiling ranges correspond to Sweeney's and Tilton's Solvessos numbers 1, 2, 3, and 4. These overhead cuts were caustic-washed, filtered, and inspected. The yields and inspection data on these overhead cuts are given in Table III.

It will be noticed from the preceding results that a total yield of about 3.5 percent of solvents based on the crude was obtained by the extraction process. It will further be noticed that the solvents produced by extracting East Texas heavy naphtha are in every respect as good or better than the hydrogenated solvents.

That the production of paint and lacquer solvents from

[1]Sweeney and Tilton, "Industrial and Engineerying Chemistry," June, 1934, Vol. 26, No. 6, pp. 693-696.

TABLE I

Hydrogenated Solvent Naphthas

	Solvent 1	Solvent 2	Solvent 3	Solvent 4
Gravity, °A.P.I.	50.6	34.0	26.2	19.6
Aniline Point, °F.	52	−1	−10	−33
Color, Saybolt	25	23	23	0
Dimethyl Sulphate Value, percent	24.0	62.0	87.0	100.0
Gum Kauri Butonal Value	55.2	75.6	77.3	87.5
A.S.T.M. Distillation—				
Initial, °F.	168	270	352	410
10 percent off	198	293	363	423
20 percent off	206	299	372	426
30 percent off	212	305	376	429
40 percent off	220	312	380	432
50 percent off	228	317	383	434
60 percent off	237	324	387	437
70 percent off	248	332	393	442
80 percent off	260	342	400	448
90 percent off	279	358	412	458
95 percent off	298	367	422	465
Final, °F.	322	397	438	489
Recovery, percent	98.5	99.0	99.0	99.0
Residue, percent	1.0	0.9	0.8	0.9

TABLE II

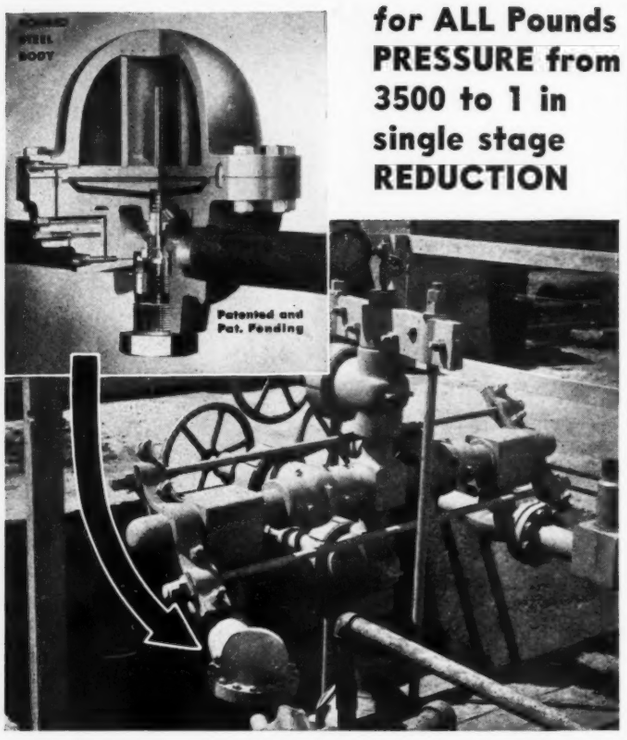
Inspection Data on East Texas Heavy Naphtha and Sulphur Dioxide Soluble and Insoluble Fractions

Column Layer	1 Charge	2 Bottom	3 Top
Yield, percent on the Charge	.....	16.1	83.9
Yield, percent on the Crude	23.0	3.7	19.3
Gravity, °A.P.I.	45.1	30.6	47.7
I.B.P., °F.	188	206	179
5 percent	220	243	212
10 percent	238	255	233
20 percent	266	278	257
30 percent	290	304	284
40 percent	315	326	310
50 percent	339	347	334
60 percent	360	371	356
70 percent	384	393	381
80 percent	412	416	408
90 percent	443	445	438
95 percent	461	462	457
F.B.P., °F.	489	492	482

TABLE III

Inspection Data on Solvents Produced from East Texas Heavy Naphtha

Percent on Bottom Layer	0–18.5	18.5–56.0	56.0–81.0	81.0–95.0
Solvent Number	1	2	3	4
Gravity, °A.P.I.	38.6	34.1	29.6	19.7
A.S.T.M. Distillation—				
Initial, °F.	193	237	360	411
5 percent off	207	285	365	418
10 percent off	213	295	370	424
20 percent off	220	306	376	429
30 percent off	225	312	380	434
40 percent off	231	318	385	438
50 percent off	236	323	390	441
60 percent off	242	328	393	443
70 percent off	252	335	398	445
80 percent off	262	348	403	448
90 percent off	280	365	412	455
95 percent off	298	283	423	466
Final, °F.	321	399	432	479
Recovery, percent	98.0	98.0	98.0	98.0
Residue, percent	1.0	1.0	1.0	1.0
Aniline Point, °F.	−20	−15	8	12
Color, Saybolt	28	25	24	21
Dimethyl Sulphate Value, percent	86	95	98	100
Gum Kauri-Butonal Value	70	73	75	86



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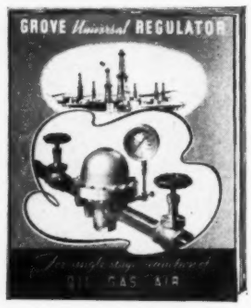

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East Texas heavy naphtha by solvent extraction has commercial possibilities is shown by the following economic analysis. On the basis of 1000 bbl. of East Texas crude oil the heavy naphtha cut as gasoline and kerosene would be worth at the refinery about four cents per gallon. From 1000 bbl. of crude there would be obtained 230 bbl. of heavy naphtha worth at the above price $386.40. Solvent-treating this 230 bbl. of heavy naphtha would yield about 35 bbl. of solvents and 195 bbl. of residue heavy naphtha. The solvents at 15 cents per gal. would be worth $220.50, and the residue naphtha at 3½ cents per gal. would be worth $286.65, or by the solvent method the products would be worth $507.15. Thus a gain of $120.75 per 1000 bbl. of East Texas crude processed is in favor of the solvent-treating procedure. Out of the increased return, however, the cost of the sulphur dioxide extraction process would have to be deducted. The extraction cost should not be large, and it would appear that refiners should consider this or similar processes.

Although liquid sulphur dioxide appears to be a very satisfactory extracting agent for separating the aromatic compounds from the non-aromatic compounds, its use is controlled, and any user would be forced to pay a royalty or obtain a license. For this reason, work is at present being carried out on other solvents, it being hoped that another solvent similar to liquid sulphur dioxide can be found that could be employed for this purpose. Work is also being carried out on the production of solvents from cracked East Texas naphtha by sulphur dioxide extraction. Preliminary results indicate that a much greater quantity of aromatic compounds exist in East Texas cracked naphtha than there does in East Texas straight-run naphtha.

Bert L. Stone of Hydril Makes Eastern Trip

Bert L. Stone, vice-president and chief engineer of the Hydril Company, has returned to his headquarters at the company's Torrance, California, plant after an extensive trip to eastern machinery manufacturing centers. He spent several weeks in Cleveland, Ohio, and Pittsburgh, Pennsylvania, investigating the latest developments in several types of machine tools preparatory to placing an order for new equipment to be added to the Hydril Company's Torrance and Houston factories. On the way back Stone visited the Oil Show at Tulsa and attended the A. P. I. meetings held in that city.

BERT L. STONE

Death of Burton L. Delack

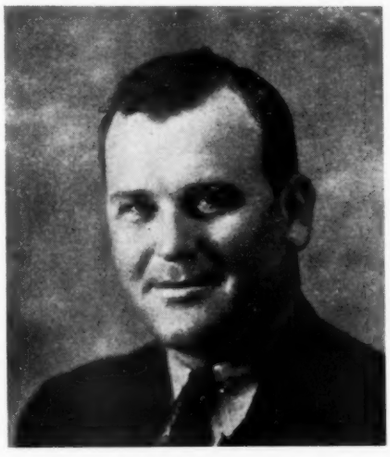
Burton L. Delack, general assistant to Vice-President W. R. Burrows of the General Electric Company and until two years ago manager of the company's Schenectady Works, died recently, following a stroke suffered at his office the previous afternoon.

Byron Jackson Company Announces Changes in Sales Staff

Byron Jackson Company, oil tool division, announce that R. L. (Bob) Gibbons will handle sales work for the company in Kansas, Wyoming, Colorado, and will cover northern Oklahoma as far as Bartlesville. His headquarters will be in Wichita, Kansas. Gibbons is well known in East Texas. Prior to his present connection with Byron Jackson Company he was manager of field sales for Atlas Supply Company at Seminole for three and one-half years and was with the same company at Earlsboro for a year.

R. L. (BOB) GIBBONS

Gibbons previously worked in the field.



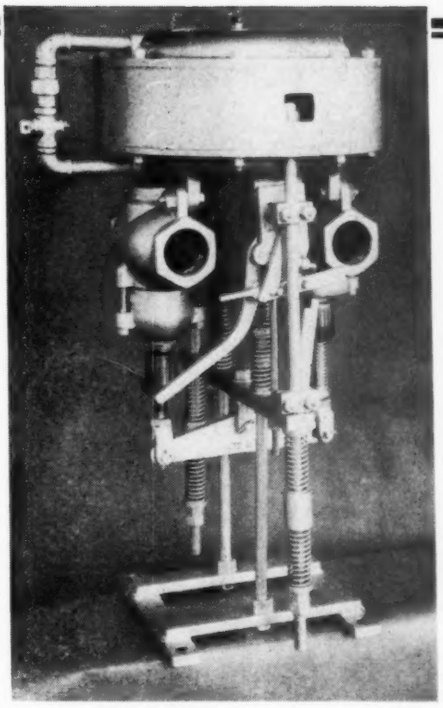
J. G. (JACK) HOOD

J. G. (Jack) Hood, who has sold Byron Jackson oil tools in South Texas and Louisiana fields for some time, has been transferred to southwest Texas. He will handle sales there and and in west Texas and New Mexico. Hood represented Baash-Ross Tool Company in Louisiana for a year before going with Byron Jackson Company.

E. L. Decker Makes Extended Trip

E. L. Decker left Long Beach the latter part of April on an extended sales trip, the first leg of which took him to Texas. From the Gulf Coast his itinerary took him to Tulsa to look after the Martin-Decker exhibit at the International Oil Show. Following the show the Mid-Continent fields were covered and he then went on to New York to look after the company's export business. Later the Rocky Mountain territory is to be visited. "Deck" will be away from his California office about four months.

E. L. "DECK" DECKER



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Thermodynamics of Vapor Heat Exchangers[1]

By R. H. TURNER

IT readily can be seen that in computing the total heat to be extracted in a liquid-to-liquid unit that there is no heat to be considered except the sensible heats of the liquids being treated, provided there is no evaporation of the cooling medium. Such heat is calculated by a product of the total pounds per hour of the liquid and the deg. fahr. through which the liquid is heated or cooled and the mean sp. ht. of the liquid at the average temperature.

This is not the case, however, when determining the total heat to be extracted in the shell of a vapor condenser and cooler, which problem presents a much more complex set of conditions, all of which must of necessity be treated correctly to arrive at a satisfactory practical solution.

In the case of the steam condenser, condensation of the steam takes place completely at one, and only one, temperature, whereas, in the vapor condenser, the condensation of the hydrocarbon vapors takes place over quite a wide range of temperature.

Where oil vapors are being cooled, condensed, and the condensate being cooled, the total heat to be extracted in the shell of the vapor unit can be split in the following manner:

A. Sensible heat from vapor cooling.

B. Latent heat from vapor condensation.

C. Sensible heat from condensate cooling.

The above is the simplest form of oil vapor condenser and the problem may yet be made more complex by the presence of large quantities of fixed gases or steam that have a condensation temperature to be arrived at from the mols present to the mols of oil vapors present and the absolute operating pressure, which will usually be a temperature materially different from the temperature at which the major portion of the oil vapors will be condensed. When either or both of the above cases prevail, it is only necessary for each of the components, besides the oil vapors, such as the steam or fixed gases, to be treated the same as above separately and individually from the oil vapors. The total heat to be extracted being an integral, or sum, of the totals of each. The above statements are true not only for the necessity of arriving at the correct total heat to be extracted from the shell of the condensers, but also from the standpoint of being able to arrive correctly at the log mean temperature difference that should be taken to determine the sq. ft. of surface necessary for the expenditure of each separate and distinct type of heat.

To bring out more conclusively the above statements it is thought well to assume a hypothetical problem and solve it in detail, explaining the steps as taken:

Problem:

Quantity of oil vapors entering condensers	25,000 lb./hr.
Quantity of steam entering	1,800 lb./hr.
Inlet temperature of vapors and steam	420 deg F.
Inlet pressure of vapors and steam	55 mm. Hg.
Outlet temperature of fixed gases and condensate	90 deg. F.
Allowable vapor pressure drop	5 mm. Hg.
Inlet temperature of cooling water	75 deg. F.
Outlet temperature of cooling water	125 deg. F.
Allowable water pressure drop in tubes	10 lb./sq. in.
Gravity of gas oil	30 deg. API.

From the vaporization curve in Fig. 7 of the gas oil being cooled and condensed, it can be seen that the initial boiling point at the above vacuum is approximately 250 deg. fahr. and the end point is approximately 425 deg. fahr., with 50 percent vaporized at 348 deg. fahr. Condensation of oil vapors occurs over the entire above range, but for all practical purposes it can be satisfactorily assumed, in order to simplify computations materially, that all the oil vapors are cooled without condensation to 348 deg. fahr., that total condensation occurs at this point, and that the total amount of condensate is cooled from 348 deg. fahr. to 90 deg. fahr.

It readily can be calculated from the data given that the steam condenses at 100 deg. fahr., consequently the total heat to be extracted because of the steam must comprise the following: 1. Cooling the steam as a gas from 420 deg. fahr. to 100 deg. fahr.; 2. Condensation of the steam at this point; 3. Cooling the condensed water from 100 deg. fahr. to 90 deg. fahr.

From the above considerations, the total heat to be extracted by the water is as follows:

Cooling of oil vapors— $25{,}000 \times (420-348) \times 0.508 =$	914,000 B.t.u./hr.
Condensing oil vapors— $25{,}000 \times 113$ (latent heat) $=$	2,825,000 B.t.u./hr.
Cooling condensate— $25{,}000 \times (348-90) \times 0.536 =$	3,458,000 B.t.u./hr.
Cooling steam vapors— $1800 \times (420-100) \times 0.464 =$	262,000 B.t.u./hr.
Condensing steam— 1800×950 (latent heat) $=$	1,710,000 B.t.u./hr.
Cooling water— $1800 \times (100-90) \times 1.0 =$	18,000 B.t.u./hr.
TOTAL DUTY - - -	9,187,000 B.t.u./hr.

Having arrived at the complete duty of the units, it next is necessary to arrive at the correct mean temperature difference to be used for each of these components. This step more easily can be understood by referring to the curves shown in Fig. 8. The heat is given up to the water by these several different components at different temperatures, as shown in the curves. The cooling of the oil vapors takes place entirely above 250 deg. fahr., and largely at greater temperatures, since the quantity of vapors to be cooled decreases as condensation increases. Condensation of the vapors occurs throughout the entire range of temperature, but chiefly between 310 deg. fahr. and 370 deg. fahr., as shown by the vaporization curve in Fig. 7.

[1]This is the conclusion of article, "Vapor-to-Liquid Heat Exchangers and Condensers" by R. H. Turner, which appeared on p. 23 of the May issue.

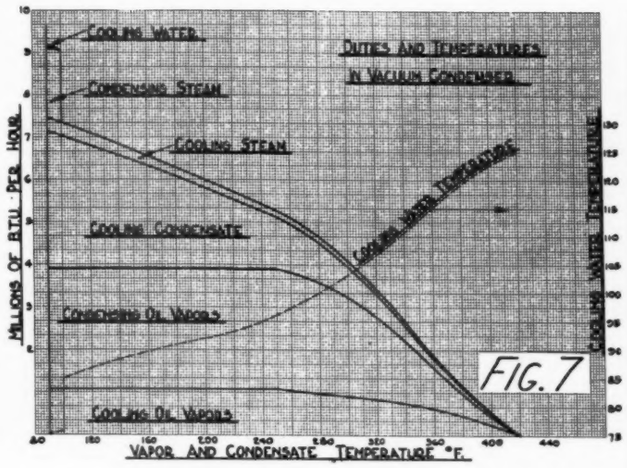

FIG. 7

Cooling of the condensate, however, is negligible at the higher temperatures, since there is very little to be cooled, but becomes more important as a temperature of 250 deg. fahr. and total condensation approaches. The factors of cooling the steam and after condensation, the cooling of the resultant water, are not of sufficient size to be materially considered and naturally would not affect the total unit to any appreciable degree; however, nearly 20 percent of the duty is from steam condensation and is an important factor. Since the steam will condense at the practically constant temperature of 100 deg. fahr., it readily can be seen that this is the temperature at which this L.M.T.D. should be calculated.

From an examination of the curves and the above, the fallacy of taking an overall L.M.T.D. for the water and oil vapors plainly can be seen. Such a L.M.T.D. in this problem is 97 deg. fahr. The true L.M.T.D.'s, based upon the temperatures at which the transfer of heat actualy occurs, are as follows:

Cooling oil vapors—
270 deg. F. (278% of overall L.M.T.D.)

Condensing oil vapors—
216 deg F. (223% of overall L.M.T.D.)

Cooling condensate—
73 deg. F. (75% of overall L.M.T.D.)

Condensing steam—
19 deg. F. (20% of overall L.M.T.D.)

Having determined the respective duties in the condensers and the correct L.M.T.D. to be used in treating each, it next is necessary to determine the correct heat transfer rate to be used for each component part.

1. Cooling Oil Vapors and Steam:

The film transfer rate for cooling gases is a direct function of the velocity of the vapors (usually expressed in ft./sec.) and the vapor density, or specific volume; however, a selection of this transfer coefficient is necessarily restricted, because the allowable pressure drop on the vapors is set at a maximum of five mm. Hg. The pressure drop in any vapor condenser can be calculated from the following formula:

$$\text{Pressure drop (lb./sq. in.)} = \frac{\text{Length of travel (ft.)} \times \text{Velocity (ft./sec.}^2\text{)}}{\text{Sp. vol. (cu. ft./lb.)} \times \text{Constant.}}$$

In the above formula the length of travel is a value to take care of baffles, reversals of flow, etc. The factors of allowable pressure drop and specific volume are set by the specifications of each particular case, but the selector must

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select the velocity and length of travel that best and most economically will meet the conditions given.

In this problem, let us assume that it is desired to select this condensing unit in three sections and that the tube length because of some local condition is restricted to 12 ft.-0 in. Then the linear travel of the vapors through each section is approximately 11 ft.-0 in., to which must be added 15 in., which represents the velocity head losses due to the reversals of flow of the oil vapors. Thus the total length of travel through three sections, or units, is: $3 \times (11 \text{ plus } 1.25)$, or 36.75 feet. The average specific volume of the vapors is computed to be 135 cu. ft./lb., and the allowable pressure drop is five mm. Hg., or 0.097 lb./sq. in. Substituting these values in the formula, it is found that the maximum velocity permissible is 62.50 ft./sec.

By referring to heat transfer rate curves it is found that the film coefficient for cooling vapors having a specific volume of 135 and a velocity of 62.5 ft./sec. is 5.40 and this value is assigned to the vapor cooling component.

2. Condensing Oil Vapors:

The film coefficient for condensing oil vapors is solely a function of the film viscosity and the conductivity of the condensate; therefore, the condensing coefficient can be taken directly from a curve in which film coefficient is plotted against film viscosity. The film viscosity is 36 SSU and the film coefficient is 67.

3. Condensing Steam:

The film coefficient for condensing steam in the presence of oil is taken as a constant of 480, regardless of velocity or density. This value cannot be used where pure, clean steam is being condensed, as in a power plant condenser, where values as high as 5000 B.t.u. can be satisfactorily realized. The figure of 480 B.t.u. is as has been determined from a great number of actual field tests.

4. Cooling Condensate:

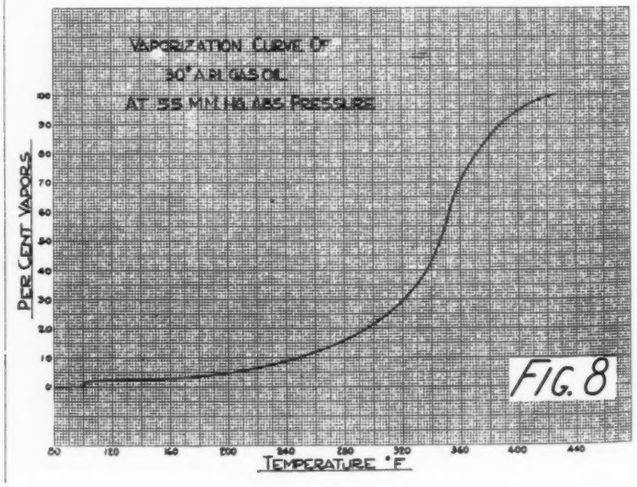
In arriving at this coefficient two factors must be considered:

(a) The film viscosity of the condensate.

(b) Velocity expressed as a coverage factor. Expressed in terms of lb./ft. of tube/row of tubes/hour.

In the case of our example, the corrected film coefficient for cooling the condensate, which has a film viscosity of 45 SSU, 31 B.t.u.

We have now determined practically all the component solutions of the condensing unit and the remainder need be



very little more than a summation of the foregone calculations:

DUTY—	B.t.u./hr.	ho	hl	H*1	MTD	Surface
Cooling oil vapors	914,000	5.4	300	5.3	270	639
Condensing oil vapors . . .	2,825,000	67	300	55	216	238
Cooling oil condensate . . .	3,458,000	31	300	28	73	1690
Cooling steam	262,000	5.4	300	5.3	95	520
Condensing steam	1,710,000	480	300	185	19	487
Cooling water	18,000	31	300	28	19	34
	9,187,000			26.2	97*2	3608

$9{,}187{,}000/97 \times 3608 = 26.2$

*1 $H = (ho \times hl)/(ho + hl)$
*2 97 = Overall L.M.T.D.

It will be observed that we have assumed a water film coefficient of 300 B.t.u. and this must be checked; however, a very large change in this coefficient will not affect the overall heat transfer rate sufficiently to cause any change in the assumption, in all probability.

It can be observed that an overall coefficient of 26.6 B.t.u. has been arrived at in the above summation, based upon the total duty, the overall L.M.T.D. and the total surface required.

Water required $= 9{,}187{,}000/500 \times 35$ (rise in temp.) $= 370$ GPM.

Having determined that a total of 3600 sq. ft. of surface is required and that this surface is to be split into three 1200 sq. ft. units having a tube length of 12-ft-0 in., the rest of the design becomes a purely mechanical operation. The first item to be checked is the free area required for the passage of the vapors. These have a volume of 712 cu. ft. at the inlet and 17 cu. ft. per sec. at the outlet, or a mean vapor volume of 503 cu. ft. per sec. (The square root of one-half of the sum of the squares).

Inasmuch as our design was based on a vapor velocity of 62.5 ft./sec., we will require a free area of 503 divided by 62.5, or 8.02 sq. ft. Each tube element will contain 382 1-in. O.D. tubes having a tube length of 12 ft-0 in. with a total cross sectional area of 2.08 sq. ft., making a total sectional area of 10.1 sq. ft. for each bundle; the bundles therefore will have to be 43 in. in diameter to accommodate the number of tubes above, which will be spaced on a 1¾-in. diamond pitch.

Since 370 GPM of cooling water are required for this condenser each section should contain six water passes, giving a water velocity of 3.4 ft./sec., a total pressure drop of 9 lb./sq. in., and a water film coefficient of 380 B.t.u.

Our final design, therefore, consists of three 1200-sq. ft. sections, each containing 382 — 1 in. O.D. × 12 ft.-0 in. tubes, arranged in six water passes and spaced on 1¾-in. diamond pitch.

Chas D. Wagner and E. E. Stevenson Visit Mid-Continent

Chas. D. Wagner, vice-president and manager, accompanied by E. E. Stevenson, chief engineer, of the D + B Pump & Supply Company, of Los Angeles, California, attended the mid-year meeting of the American Petroleum Institute, and the International Petroleum Exposition and Congress, after which they spent some time at the company's enlarged plant recently completed at Dallas, Texas. Before returning to Los Angeles they covered the Mid-Continent and Gulf Coast fields for the purpose of making a general survey of conditions in those territories.

CHAS. D. WAGNER

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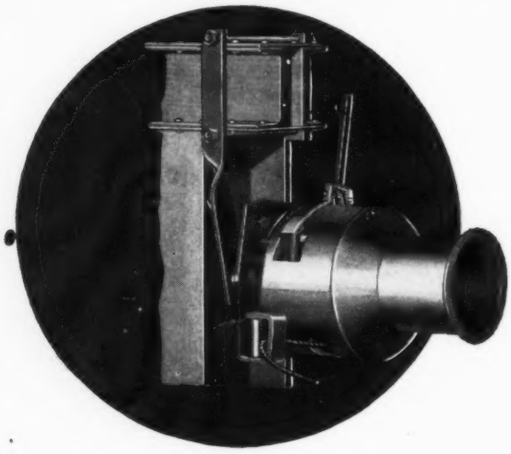

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